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WASTE MANAGEMENT CONTROL HANDBOOK FOR DAIRY FOOD PLANTS

by

W.J. Harper
Department of Food Science and Nutrition
The Ohio State University
Columbus, Ohio 43210

Roy E. Carawan
Department of Food Science
North Carolina State University
Raleigh, North Carolina 27607

M.F. Parkin
New Zealand Dairy Research Institute
Palmerston North, New Zealand

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Project Officer
Fred W. Craig
Food and Wood Products Branch
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

OFFICE OF RESEARCH AND DEVELOPMENT
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Waste control is resource management control in dairy food plant operations. Appreciable reductions can be achieved in product, water, energy, labor, packaging losses and sewer surcharges. A good program in waste control can increase the profit margin by more than 10%, as well as being a program that helps improve the environment in which we live. Another result of the operation of an effective waste program is to increase the overall efficiency of a dairy food plant. Waste control should be recognized as being equal in significance to quality control and justifies the assignment of one or more individuals to the waste control program with resulting economic gain to the dairy food plant. This Handbook is predicated on the viewpoint that an effective control program requires the full attention of a responsible person reporting directly to the plant manager. Details are presented in this manual on the implementation of this strategy. Maintenance programs are suggested for implementation as well as the need for an educational program for acquainting management and operators with a background in dairy food plant waste, in specific plant principles, and with a longer term continuing in-plant educational program.

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a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Field Study Full Scale Assessment Food Wastewater Conservation/ Wastewater Reuse Opers/Maint/Reliability	Dairy Food Plant	

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment, and even on our health, often require that new and more efficient pollution control methods be used. The Industrial Environmental Research Laboratory-Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This Handbook is a product of the above efforts and is directed primarily towards those individuals who have the direct responsibility for the development and operation of a waste control program in a dairy food plant. The information presented in this Handbook is focused on the minimization of losses of product, energy, water, and labor in the manufacture of dairy food products that will also economically and effectively minimize the impact on the environment and meet Federal, state, and local regulations.

Such information will be of value to various dairy regulatory agencies and to the industry itself in arriving at meaningful or achievable solutions to environmental problems either through a municipal discharge or through discharge to public waters. The achievement of these goals requires a complete dedication on the part of industry management and a sufficient promotion by industry and government to provide the needed motivation for success.

For further information concerning this subject, the reader should contact the Industrial Pollution Control Division.

David G. Stephan
Director
Industrial Environmental Research
Laboratory

PREFACE

The reduction in loss of product, water and energy in dairy food plant operations is a goal toward which all dairy plants must strive in the coming years to improve profits, to minimize impact on the environment and to meet Federal, State and local regulations. This Handbook is directed primarily towards those individuals who have the direct responsibility for the development and operation of a waste control program in a dairy food plant.

Losses can be categorized as: (a) unavoidable, and (b) preventable. Unavoidable losses are related to plant and process design and are primarily those associated with cleaning operations. Preventable losses, usually over 50% of all losses, are those that can be eliminated by good operational practices. A waste control program is aimed at eliminating preventable losses and using engineering improvements in equipment and process design to minimize the level of unavoidable losses.

The information presented in this document has been developed primarily from experiences gained in working with waste control programs in milk, ice cream and cottage cheese plants. Although many of the illustrations and examples cited will come primarily from those products, the principles expressed will apply equally in plants manufacturing any dairy product. The manual also should have value in the development of waste control programs for plants throughout the food industry.

Experience has shown that the approaches outlined in this Handbook do work and can reduce product losses, organic waste loads, water loss and energy wastage by at least 50% in an average plant, but only when fully supported at all levels of management and operational personnel. The success of the program depends upon the motivation of people and providing continued attention to a well-organized program. All too often a control program is instituted, works very well in the beginning; and then because of lack of continued attention, the waste situation rapidly returns to where it was before the program was put into effect.

Waste control is really resource management control and is an important part of dairy food plant operations. The authors feel that waste control (quantity control) should be recognized as being equal in significance to quality control. For this reason, where plant size warrants, the task is large enough to justify the full-time assignment of at least one individual to the waste control program. As stated previously, only when somebody is giving this area full-time attention can long-term benefits be gained. The work to be done will often be beyond the capacity of a single individual, and never can be achieved by part-time effort. In most situations, the time spent by one or more individuals will be repaid to the company multi-fold over a time period of a year.

ABSTRACT

Waste control is resource management control in dairy food plant operations. Appreciable reductions can be achieved in product, water, energy, labor, packaging losses and sewer surcharges. A good program in waste control can increase the profit margin by more than 10%, as well as being a program that helps improve the environment in which we live. Another result of the operation of an effective waste program is to increase the overall efficiency and productiviity of a dairy foods plant. Waste control (quantity control) should be recognized as being equal in significance to quality control and justifies the assignment of one or more individuals to the waste control program with resulting economic gain to the dairy food plant.

The overall objective of any waste control program is the minimization of losses of product, energy, water and labor to the greatest extent possible. The achievement of this goal requires a complete dedication of management. A philosophy must be adopted in any dairy food plant that encourages communication between plant operators, foremen and upper levels of management. At the same time, information provided by the operators at the top management through middle management levels has to receive attention, or these communication channels will close and nothing will ever be accomplished.

The authors have found that in the majority of dairy food plants, those who operate the equipment are most familiar with it and frequently have a knowledge of simple, direct and effective means of reducing product loss, water usage and energy utilization. A most effective means of developing an ongoing program is to instill pride in the total employee force of the dairy food company. The authors conclude that at least 50% of the waste in dairy food plants is preventable, and the prevention of this waste depends upon the input of human effort, so management must also be people-oriented.

This Handbook is predicated on the viewpoint that an effective control program requires the full attention of a responsible person reporting directly to the plant manager. Details are presented in this manual on the implementation of this strategy.

A waste control program requires continuing knowledge of product, water, and associated loss that can only be ascertained through a continuing program of direct measurement of losses in the outflow from the plant. Methods of

measurement analysis and calculations of losses are provided.

Preventable wastes are shown to be a large percentage of the total waste and can often be traced to maintenance or maintenance-operator interrelated problems. Therefore, the need for strong cooperation between plant engineers and equipment operators is stressed. Recognition must be given to the fact that maintenance is not just the job of an engineer, but also involves the operator, whose daily care of the equipment can go a long way towards making it operate properly. Maintenance programs are suggested for implementation.

The need for an educational program is also stressed as being essential in a successful operation of an overall waste control program. An educational program is presented requiring three general phases: (a) an indoctrination program to acquaint management and operators with a background in dairy food plant waste, their significance and sources; (b) a how-to short-term educational program to indicate the general principles in waste management control applicable to the particular plant involved; and (c) a long-term continuing in-plant educational program.

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A. BACKGROUND INFORMATION

The major pollutant and waste discharged from dairy plants is organic material. This is milk diluted with water discharged as wastewater. When dumped untreated into a stream or river, this organic material is decomposed by microorganisms in the river. When breaking down the organic pollution, the microorganisms consume oxygen in the water. That can degrade the water by depleting its oxygen content. Oxygen depletion, in turn, can have a catastrophic impact on life in the water body for fish or other aquatic animals and plants which must have dissolved oxygen to survive. When all oxygen in a water body is used up, and this frequently happens, the decay of organic matter continues without the oxygen. As a result, noxious gases such as hydrogen sulfide and methane are produced and smell much like a septic tank.

The measurement of pollutants that consume oxygen in water is called biochemical oxygen demand, or BOD. Water with high BOD contains a large amount of decomposed or organic matter. Another major pollutant in dairy plant discharges is suspended solid waste, such as coagulated milk, particles of cheese curd, and in an ice cream plant, pieces of fruit and nuts. Measurement of this pollutant is called total suspended solids, or TSS. These solids discolor and cloud the water. They impair photosynthesis in the aquatic plants. They can settle on the bottom and become sludge beds and further deplete the waters' oxygen content. As the sludge decomposes it gives off gases that are toxic to aquatic life and cause other problems.

In addition to the adverse aesthetic and ecological effects, suspended solids and water from streams used by industry can interfere with many industrial processes. They can cause foaming in waters, damaged equipment, and impose high purification costs on industries that need clean water to make their product, such as the pharmaceutical industry. The key point is this, that raw wastes from the dairy plant contain excessive amounts of organic materials and suspended solids. The wastes thus have to be treated before they can be discharged in the water body. The major dairy industry water pollutants, organic materials and suspended solids, can be treated successfully either by a treatment plant that the dairy plant operates, or by a typical municipal system. Other identified pollutants in dairy plant wastes that may be of concern include phosphorus, nitrogen, chlorides and heat. Another consideration is the pH of the wastes. Whey has been noted to, in some situations, create a problem for municipal treament plants. This usually has been where the whey discharge was a significant portion of the load to the municipal plant.

The wastewater characteristics for dairy plants are very variable. For example, numerous authors who have studied dairy wastewaters have indicated that the wastewater parameters may have a range such as shown:

Dairy Wastewaters

BOD5 - 500 to 5,000 mg/l

SS - 400 to 3,500 mg/l

Fat - 200 to 3,000 mg/l

Flow - 0.5 to 20 pounds per pound of product

A waste treatment program has several objectives: (a) meeting all legal requirements of local, State and Federal agencies, (b) improvement of the environment through reduction in organic wastes, water usage and energy utilization, and (c) economic gain by elimination of all preventable losses.

1. Legal Reasons for Developing a Control Program

First, the various dairy regulatory agencies penalize plants that exceed certain product loss levels, usually about 2% of the milk received into the plant. Research into the waste water of dairy plants has indicated that many dairy plants are actually losing 5-8% of their raw milk inputs. The reason for the discrepancy between the reported 1% and the actual 5-8% is the difference between true mass balance records and the accounting records that are generally kept by dairy plants.

Most dairy plants discharge to municipal sewage systems. Therefore, most municipalities, to protect their systems, have passed sewer use ordinances (see Appendix 7). Many of these sewer use ordinances have very restrictive provisions in regard to what materials can and cannot be discharged into the system. Frequently, these ordinances are not rigidly enforced; however, specific restrictions that affect dairy processing plants include upper pH limits of pH equal to 9, maximum BOD discharge of 300-2,000 mg/l, etc. Often, there is included in a sewer use ordinance the possible requiremments for pretreatment of dairy waste waters. However, the United States EPA and many municipalities have already concluded that pretreatment of dairy wastes is not needed unless there is an unusually large dairy plant creating over 25-50% of the municipal plant load.

Plants that are treating their own wastes and directly discharging to the surface waters come under the requirements for the NPDES permits, and also state permits. Most states do have control of the Federal NPDES permit system and coordinate it with their own permits. For these plants, there are rigid requirements as to what they can discharge to the receiving streams. The 1983 best available treatment guidelines note that in-plant control practices are necessary to reduce the load going to the treatment system to minimize the discharge of the parameters controlled.

2. Economic Reasons for Developing a Control Program

Water and sewer charges for dairy processing plants have been noted to exceed $50,000 per month for larger or less well managed dairy plants. Water and sewer charges are probably less than $2,000 a month for the average dairy plant. However, surcharges can approach $5,000 to $10,000 per month for the typical dairy plant. Waste treatment plants for a large dairy processing plant can cost $1.5 to $2.5 million to meet rigid effluent standards. There is a strong economic incentive because the cost of water, sewer and surcharge can cost something over 1/3 of a cent per gallon for a well-operated dairy plant. Plants without adequate waste control programs can have municipal bills for water, sewer and surcharge to exceed 1 cent per gallon of processed products. When the average dairy plant makes only 2.6% profit based on sales, and over 2/3 of a cent per gallon of profit can be gained from waste control, then waste control should be economically interesting to every dairy plant.

The increase in cost of energy also relates to waste control programs. Much of the product that is lost during processing has been pumped, chilled, heated, homogenized, etc., with a great expenditure of energy. Also, the cleaning processes require great quantities of warm or hot water and the energy costs of heating this water are large. Therefore, the control of waste also controls energy losses.

Other key considerations in any loss control program include prevention of lost ingredients such as sugar, milk powder, chocolate powder, etc. Another relevant feature of the waste control program is that through waste control programs the usage of CIP chemicals, COP chemicals, and floor cleaning and lubricants is often greatly reduced.

3. Energy Savings from Waste Management

Another key area of major concern to dairy processing plants at the present time is the conservation of energy. The conservation of energy is not only important for economic reasons but in case of limited supplies, the more efficient plants will be able to process more product for a given amount of energy. Much of the product that is lost from a dairy processing plant has energy that has been used in processing that is also lost when this product goes down the drain. For instance in fluid products processing, milk that is lost is largely lost after the milk has been received, pumped, pasteurized and cooled. In fact, recent research has shown that perhaps 65% of the lost product in fluid milk processing has already been pasteurized and cooled.

In ice cream processing the majority of the lost product has been pumped, pasteurized and cooled. In fact, recent research has shown that probably almost 100% of the ice cream mix that is lost has been pumped, pasteurized and cooled, and over 70% of the ice cream has already been frozen. Thus, the potential for savings of product not only saves the product itself but the energy that has been expended in processing that product.

Most dairy food plants discharge their wastes to municipalities and need to be aware of local, State and Federal regulations that may directly or indirectly impact on their waste control programs. Local regulations vary widely in waste parameters and regulations and thus affect any monitoring and control program.

4. Sewer Ordinances

Most municipalities have sewer ordinances. Those that don't will probably institute sewer use ordinances in the near future. Public Law 92-500 as amended by Public Law 95-217 requires that municipalities institute industrial cost recovery, assist in the user charges and have a sewer use ordinance if they obtain Federal funds for water and waste water facilities. Almost all municipalities use Federal funds when they build or expand their current sewer system. Industry must assist the municipality in the development of a practical and sound regulatory ordinance fit to local conditions. Industry should want the minimum number of restrictions that will protect municipal systems, and should encourage an ordinance that is technically sound and rigidly enforced.

The sewer use ordinance is used to refer to the "sewer ordinance" defined as "an instrument setting forth rules and regulations governing the use of the public sewer system." In most cases, the industrial cost recovery and surcharge or user charge system will be a part of this instrument.

Public Laws 92-500 and 95-217 put some specific requirements on municipalities using Federal funds to help build sewer systems for municipalities. Plant management needs to be aware of these requirements, which are detailed in Appendix 7.

5. Municipal Charges

Most dairy plants get a municipal billing for their water and sewer. This consists of two to four components; first, there is a water bill; then there is attached a sewer charge; and in many cases there is a surcharge; and finally, there may be an industrial cost recovery bill.

Water

The water bill is for the water metered into the plant through the municipal meters. Generally most municipal meters for industrial dischargers measure the water use in cubic feet, and charge on the number of hundreds of cubic feet or thousands of gallons of water which the plant received during the billing period which is most often a month. The water bill is computed by multiplying the units of water received times some cost factor per unit. The cost of water often varies depending on how much water a dairy plant uses, and generally the more water you use, the cheaper the rate at which you get the water. This is called a declining block water rate structure. However, some municipalities have now gone to a unit pricing water system in which you are billed for each unit of water at one cost per unit. Some places have even adopted an increasing block water rate structure in which the more water you use, the greater your charge per unit of water.

In interpreting a water bill, remember that a cubic foot of water is equal to about approximately 7.48 gallons. An average dairy plant utilizes about two to three gallons of water to process each gallon of milk.

The cost of water in the United States ranges from $0.10 to $1.00 per thousand gallons of water used.

Sewer Charge

The next charge on the municipal bill is a sewer charge. The sewer charge is computed by multiplying some fraction times your water bill. This is generally anywhere from 10 to 200% of your water bill. In other words, if the water bill is $300.00 and the sewer charge is 100% of the water bill, then the total water and sewer charge will be $600.

Surcharges

Many cities now have sewer use ordinances and included in these are user charge or surcharge sections. Most dairy plants have found that user charges or surcharges can quadruple their municipal billings. A surcharge or user charge is levied for wastewaters found to have strong waste levels or loads to the city sewage system. The most common basis for surcharges or user charges is biological oxygen demand (BOD) load. The BOD is discussed elsewhere in this handbook, but is generally regarded as a measure of the strength of the waste discharged to the city sewer system. In most cases surcharges are also levied on suspended solids (SS). Often plants are allowed to discharge BOD and/or SS levels up to normal strength of domestic waste with no surcharge. Surcharges have been levied in some municipalities for fats, oils, and grease (FOG) and nitrogen.

BOD and SS surcharges vary widely from $0.01 to $0.50/pound averaging about $.08 to $0.10/pound of each for municipalities operating under Federal Grants Programs.

Industrial Cost Recovery

In addition to the above, Public Law 92-217 required municipalities to collect ICR or industrial cost recovery charges from industries discharging to municipal systems. These charges are designed to help the municipality and the Federal Government recover that portion of the costs which are attributable directly to the discharge of the industrial plant. Presently under the 1977 Water Act Amendments, there is a moratorium on the collection of ICR charges. The costs are too variable to guess what any individual plant would be charged.

Questions About Your Sewer Bill

Any dairy plant needs to ask a number of questions about their bill from water and sewer services. A number of these questions are the following:

- What do you pay for water?
- What do you pay for sewer?
- What do you pay for surcharge?
- What is the trend?

- Does the trend follow production?

Someone in each plant should have responsibility for checking the accuracy of the bills. This individual should compare his charges with similar plants from neighboring communities. Also, you should compare their water use with the water use for similar production plants. Similar questions should be asked about water, sewer, and surcharges, such as Do the bills follow production trend? In other words, When fruit drink production is very heavy, does the water usage increase? If so, good. If not, then why are there changes in the water use and why are there changes in the sewer and surcharge bills? In particular, a number of questions should be asked about the surcharge bill. These questions should include the following:

- For which characteristics are you paying?
- Do these characteristics vary widely?
- Does your flow vary widely?
- How does your bill compare with similar plants?

The surcharge bill depends to a large extent on the surcharge calculation and the sampling program. A number of questions should be asked about the city sampling programs, including What method does the city use to sample? For example, Does the city use a time composite sampler, or does the town have a proportional, composite sampler? Does the town follow reliable analysis methods, and do the results agree with what one would expect from a dairy plant? A real problem with many municipalities is flow measurement. Flow measurement for the small flows that come from dairy plants is a real problem. A final question to ask is in regard to the validity of the results. Are accurate notes kept by the city on the sampler, the person taking the sample, method of storage of the samples, who performed the sample analysis, who computed the results, and are the results transferred in an orderly fashion to the industrial plants?

After assurance that the sampling program is okay, the next possible problem area is the surcharge calculation itself. A number of questions about the surcharge calculation procedure include the following:

Surcharge Calculation

- What characteristics determine the charge, flow BOD5, SS, peak flow, demand?
- Area average characteristics used

- What is the charge for each characteristic?
- What flow is used?
- How often are samples taken?

The computation of the average characteristics in itself can lead to a number of problems. For instance, if the city samples for three days, does it average the samples based on concentration or does it compute a weighted mean based on flow, which would be more indicative of your wastewater flow. The question of how often the samples are taken is significant. If the city samples too often, you will pay for these charges in your bill, and will get no benefits. If, however, the city takes the samples on a less rigid schedule, then the values may not be representative.

A typical multiproduct dairy might have wastewater parameters such as the following:

Multiproduct Dairy Plant

Production - 50,000 gallons of milk per day

Water Use - 150,000 gallons per day

Wastewater - 100,000 gallons per day

BOD5 - 3156 pounds per day

SS - 1540 pounds per day

Fat - 1006 pounds per day

The water, sewer and surcharge bill would look something like the following:

Dairy Monthly Costs

(Production 50,000 gallons of milk/day)

Water ($.25/1000 gallons)	$ 825.
Sewer (100% of water bill)	825.
Surcharge ($.075/lb. BOD5)	4691.
($.075/lb. SS)	2316.
TOTAL	$8657.

The figures shown above of $8657 per month for a 50,000 gallon of milk per day dairy plant would represent a cost per gallon of milk of about $.0087.

Specific problems can be presented by discharging the whey from cottage cheese manufacturing facilities. For example, it can be computed that if just a BOD5 surcharge is charged of 7.39 cents per pound, then the cost per pound of finished cottage cheese will be about 1.7 cents for the treatment of the BOD from the whey. A couple of calculations follow:

Cottage Cheese Whey Discharge

BOD5 Surcharge	Cost/Lb. Cottage Cheese
3.54 cents/lb.	0.9 cents
7.39 cents/lb.	1.7 cents

The disposal of cottage cheese whey to a municipal system for a large cottage cheese producing facility is prohibited by cost if the city accurately determines the plant's waste discharge. An effective waste control program can reduce these costs markedly.

6. Direct Dischargers and NPDES Permits

There are more than 5,000 dairy products plants in the United States, employing about 198,000 men and women. They produce milk, cream, butter, cheese, ice cream and a variety of other dairy products. The United States EPA has estimated that dairy plants produce about 60 million pounds of waste each year. These wastes include 40 million pounds of organic material, equivalent to the sewage generated by 6-1/2 million people. Some 4,000 dairy plants send their waste discharges to publicly owned sewage facilities, where the pollutants are treated along with the wastes from homes and other industries. About 1400 dairy plants discharge their waste directly into water bodies. These dischargers are required to keep their wastes from polluting the nation's waters and to have NPDES Permits developed under PL 92-500 and PL 95-217.

Effluent Guidelines

In response to widespread public concern about the condition of the nation's waterways, Congress enacted the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500), which are subject to alteration under Public Law 95-217. More detailed information is found in Appendix 7.

Public Law 92-500 says, in essence, that nobody - no city or town, no industry, no government agency, no individual - has the right to pollute our water. The free use of our waterways as a dumping ground for our wastes as has been acceptable in the past is no longer permitted. Congress declared that the objective of the 1972 law is "to restore and maintain the chemical, physical, and biological integrity of the nation's waters." Congress dictated that EPA establish national "effluent limitations" for industrial plants, including dairy product plants. An effluent limitation is simply the maximum amount of pollutant that anyone may discharge into a water body.

By July 1, 1977, the law required existing industries to reduce their pollutant discharges to the level obtainable by using the best practicable water pollution control technology (BPT). BPT was determined by averaging pollution control effectiveness achieved by the best dairy wastewater treatment plants in the industry.

Determination was also made of the "best available" pollution control technology (BAT). The law requires existing industries to reduce their pollutant discharges still more from the BPT levels to the BAT levels by July 1, 1983. BAT was based on the best pollution control procedures economically achievable. Industries were required by Congress to completely eliminate pollutant discharge by July 1, 1983, if it was proven technologically and economically feasible to do so.

Under PL 95-217 a new waste category was established - "Best Conventional Pollutant Control Technology" (BCT). For dairy plants, however, BCT = BAT under PL 92-500.

The law requires new industrial plants to limit pollutant discharges to the level obtainable by meeting national "standards of performance" established by EPA for new plants. A new plant must meet these standards immediately without waiting for 1983. For the dairy industry, the new plant standards or standards of performance are equivalent to the 1983 BAT standards.

PL 92-500 requires that industrial facilities sending their wastes to municipal treatment plants, as most dairies do, make sure their wastes can be adequately treated by the municipal plant and will not damage the municipal plant. In some industries, discharge to municipal plants may have to be pretreated. That is, the portion of industrial wastes that would not be adequately treated or might damage the municipal plant must be removed from the waste before it enters a municipal system. However, experience by most municipalities in the United States and information established by EPA has indicatd that dairy wastes are compatible and can be treated by properly operated municipal facilities.

States have been given the authority to enforce the Federal Standards. Most states previously required permits for direct discharges of wastewater. Then PL 92-500 set up a new system of permits at the Federal level - the NPDES or National Pollutant Discharge Elimination System Permits which were developed and promulgated by the EPA. Now, most states write and enforce the NPDES permits. However, EPA reserves the right to check on the actions of the state. While the law requires industries to follow municipal discharge standards set for 1977 and 1983 and for new plants, the law also allows a state or community to impose stricter requirements if it wishes. The national standards are thus minimum requirements that all industries must meet. Many dairy plants will find that they are discharging into water-quality limited waters and will be required to meet more stringent standards than either BPT or BAT. Under PL 92-500, it is illegal for any industry to discharge any pollutant into the nation's waters without a NPDES permit.

7. Meeting the Challenge

Thus, a dairy plant is faced with solving its environmental problems either through a municipal discharge or through discharge to public waters. Such understanding provides a basis upon which to build a control program to meet the specific conditions of the given plant. In the first, the plant management must learn and understand about their local municipal sewer use ordinance. They must thoroughly understand how the restrictions in the ordinance can or do affect their day-to-day operations. They must understand how they are or will be charged a surcharge. In some specific cases, they must understand the pretreatment requirements of the sewer use ordinance and how it affects their operations. They must either plan for these facilities and/or operate these facilities. They must assure themselves that their maintenance program assures that the facilities operate as they are designed.

Direct dischargers must keep their NPDES permits and state permits, if also required, not only up-to-date but current. Monitoring requirements must be met on a regular and specified basis. Reports must be filed as dictated by the regulatory authority.

B. INTRODUCTION TO MANAGEMENT CONTROL

1. General Philosophy and Goals

The overall objective of any waste control program is the minimization of losses of product, materials, water and energy to the greatest extent possible. The achievement of this goal requires a complete dedication on the part of management and a sufficient promotion to provide the necessary motivation for achievement of the goals.

Management should recognize that a continuing waste control program can increase profits by 10% or more in an average dairy foods plant. In numerous instances product losses (which include milk, sugar, cocoa and other dairy ingredients) down the drain are in excess of predicted losses based on production figures. The achievement of good control requires that everybody in the entire operation work cooperatively together. If the management recognizes that waste control is a portion of the profit picture, then it will be given the attention that it deserves. A philosophy must be adopted that encourages communication between the plant operators, foremen and upper levels of management. At the same time, the information provided by the operators to top management through middle management levels has to receive attention, or these communication channels will close and nothing will ever be accomplished.

In the majority of dairy food plants, those who operate the equipment are most familiar with it and frequently have a knowledge of simple, direct and effective means of reducing product loss, water usage and energy utilization.

One of the most effective means of developing an on-going program is to instill pride in the total employee force in the dairy food company. Because at least 50% of the waste in dairy food plants is preventable, and these preventable wastes depend upon the input of human effort, management must also be people-oriented.

A secondary result of the operation of an effective waste control program is to increase the overall efficiency and productivity of the plant.

Management has open to it a number of potential strategies. These include: (a) to do nothing except express a need for control procedures to be implemented; (b) the assignment of responsibility for waste control as an add-on position to somebody's existing responsibilities; (c) assignment of the responsibility to a committee; and (d) assignment of the responsibility to an individual. Of these, only the latter two will be really effective, with the last being most effective.

The detailed control plan to be employed by management will depend to a considerable degree upon the size of the organization, the complexity of the operation, the type of product(s) being manufactured, and the personalities of the individuals in management and operations.

In developing a waste control program, management needs to recognize that the success of the program will depend primarily upon the actions of the people, and their motivation. The involvement of as many people in the program as possible can be useful, provided that there is clear leadership and complete understanding of the lines of authority.

In any control program, the preventable wastes can be traced, in a large percentage of the cases, to maintenance or maintenance-operator interrelated problems. Therefore, any program should strongly emphasize the necessity for developing a strong preventive maintenance program and to also develop a strong cooperation between the plant engineers and the equipment operators. Recognition must be given to the fact that maintenance is not just the job of the engineer, but also involves the operator, whose daily care of the equipment can go a long way toward making it operate properly. Major product losses generally relate to major errors in judgment, which frequently also interrelate to equipment handling. In many cases, technical representatives from equipment manufacturers and suppliers can be tapped for assistance in developing a maintenance program.

An educational program is also essential in the successful operation of an overall control program. This educational program takes on three general phases: (a) an indoctrination program to acquaint management and operators with the background of dairy food plant wastes, their significance and sources; (b) a how-to, short-term educational program to indicate the general principles in waste management control applicable to the particular plant involved; and (c) a long-term continuing in-plant educational program. The latter should involve the specific training at all levels in terms of the specifics of the job as they relate to the proper care and maintenance of the equipment, and waste control of product, water and energy. In a large operation, an individual training office should be utilized. In many plants, the turnover of personnel is such that it's necessary to continually provide education at the operator and also at the middle-management level. In many current large dairy food plant operations, the major weakness is at the middle-management-foreman level, both in respect to management capabilities, and more specifically in respect to an adequate understanding of the detailed workings of equipment and operations. Colleges and universities today seldom train students in how-to operations. Newly hired college graduates are frequently assigned to supervisory positions without any real detailed educational indoctrination. Where feasible, these people should be hired on as plant operators to get a thorough knowledge of operation of the various types of equipment in the plant prior to becoming supervisors.

2. General Procedure for Developing a Program

The development of a waste control program involves: (a) the assignment of an individual(s) to supervise the waste control program; (b) initial fact-finding; (c) development of a specific plan of approach; (d) implementation of an education program for both management and plant operators; (e) detailed fact-finding; and (f) implementation of the waste control procedures.

The waste, or resource, control program should focus on the following areas: (a) product loss (ingredients); (b) packaging materials loss; (c) water loss; and (d) energy loss. These four are generally interrelated. The reduction of loss of finished product, for example, effects a reduction in both the water and energy used to process the product. In most cases, over 3/4 of the preventable product loss is associated with product that has been processed, and up to 1/4 of the product may be lost after packaging.

Assignment of Responsibility

A resource control program will be effective only so long as it receives continued attention and is given equal stature with quality control and/or production.

Programs have been most successful when a single individual has been made responsible and answers directly to the general plant manager. At the same time, it is essential that the Waste Control Supervisor have the full cooperation of production, quality control, and the engineering departments. To this end, generally, it is useful to form a committee composed of the Waste Control Supervisor as chairman, Quality Control Manager, Chief Engineer, Production Superintendent, and the Plant Manager, as an ex officio member.

The Waste Control Supervisor, whose duties will be detailed later, will be in overall charge of the fact-finding, analysis, and operation of the program. In many cases, he will also serve as the plant's educational director. He should be an individual who is both knowledgeable of plant operations and has demonstrated ability to work with people. A timetable for development of the program follows:

1. First Month

a) Appointment of temporary Waste Control Supervisor.

b) Collection of all old data.

c) Determination of sewer lines and outlets.

d) Survey of adequacy of monitoring station.

e) Set-up of flow monitoring and sampling station.

2. Second Month

a) Preliminary plant survey of waste volume and strength for a minimum of three weeks.

b) Determination of unavoidable and preventable losses of water and product.

c) Calculation of economic impact of wastes in respect to product (which includes all ingredients), packaging materials, water, wastewater, surcharges, labor and energy losses, all data in terms of dollar values projected to accounting periods, such as monthly and yearly periods.

d) Regulation review.

3. Third Month

a) Management meeting; presentation of program to top management.

i) Major findings of preliminary survey; economic evaluation of losses.

ii) Overview of management control program.

iii) Formalization of waste control committee.

iv) Discussion of priorities in developing management control; program suggestions for improving program development.

b) Develop visual material for educational programs.

c) Develop a series of two 2-hour programs for management.

i) Background information of dairy food plant wastes, characteristics, sources, economic impact, legal aspects; data of assessment of situation in the plant.

ii) Presentation of overall approaches to in-plant control and their application to the plant under study.

d) Presentation of program to general and supervisory management.

e) Refinement of details of control program.

4. Fourth and Fifth Months

a) Initiate control program; employ or name one individual to be in charge.

i) Develop daily control program; utilize and improve plant inspection form.

ii) Develop and utilize daily summary forms for reporting results to management to show magnitude and economic value of losses.

iii) Maintain records of daily losses; pinpoint causes.

iv) Integrate maintenance program into waste control.

v) Utilize data and work with waste control manager to improve or redirect control program.

b) Initiate detailed plant survey; installation of sampling and testing equipment for continuing program; install meters to monitor water and energy at major use sites.

c) Develop training programs for plant personnel.

5. Sixth Month

a) Conduct analyses to evaluate effect of Fourth and Fifth months' data.

b) Hold training schools (two 2-hour sessions) with plant personnel (stress environmental impact and social aspects).

i) Meeting with first-line supervisory personnel.

ii) Meeting on general background with all personnel (by groups).

iii) Specialized sessions with the operators in each department, such as:

- maintenance personnel
- milk processing personnel
- milk filling room personnel
- cottage cheese personnel
- ice cream personnel

c) Hold meeting with plant personnel to get their input into control program.

d) Make detailed studies as required to determine specific causes of preventable wastes and to identify areas for possible equipment or process change to further reduce wastes.

e) Put full control program into effect.

6. Following Months

a) Evaluate overall management control program with analyses on a continuing basis.

b) Develop modified control and training programs as needed.

Initial Fact-Finding

Initially, it is essential to assemble all the available facts possible to provide a background for the program and to help determine the additional information required. The assumption made in this Handbook is that the plant has had no previous detailed studies and no prior long-term commitment to in-plant control of its water, energy and product resources. The facts required include:

(a) Regulation Review. Obtain copies of Federal, State and local regulations that may apply to the plant in question. This would include permit requirements, municipal sewer ordinances, prohibited substances, limited substances, sampling and testing requirements, surcharges, influent and/or effluent limitations. If a permit has been granted previously, then all of the details associated with that permit need to be a matter of permanent record filed with the Waste Control Supervisor. In addition, if discharging through the plant's own treatment facility, then State and Federal regulations as they apply to the particular plant size and commodity need to be determined. In case of prior plant discharge under PL 92-500, the plant would already have completed permit information and would have some information on its waste loads.

(b) Blueprint Review. Plant site drawings should be reviewed and all sewer outlets and manhole accesses located. The drawings should give sizes and the pitch of lines. In case there are no drawings of sewer lines or outlets, then it may be necessary to determine the drainage system by the use of dyes.

(c) Prior Data. All previous survey data relating to waste volume and composition that may have been taken by the plant or local, State or Federal agencies should be collected and analyzed. This should include information in respect to the time, location and method of sampling, along with the methods used for analysis. This permits an evaluation of the probable validity of the data.

Data should also be obtained from the water company in respect to the water utilization and comparison made of incoming water volumes vs. reported volumes for wastewater. Any available data on in-plant consumption of water should also be collected.

Water metered into the plant should equal the wastewater volume plus water used in the plant minus any water discharged to the sewer system. Failure to achieve a balance indicates need for more detailed study.

Available data in respect to energy usage of electricity and fuels (gas, oil, etc.) should be collected and converted to Btu's (or metric energy units).

All available data should be calculated in terms of some unit of production. Depending on the nature and complexity of the plant, this may be expressed in terms of milk processed, final product or in terms of BOD or COD processed (see Appendix 2 for appropriate calculations). An example for a fluid milk plant would be:

300 gallons of water used/1000 pounds of milk processed

3 pounds of BOD/1000 pounds of milk processed

1.2 pounds of SS/1000 pounds of millk processed

These unit values (called water and waste coefficients in this manual) provide a basis of comparison during the operation of the waste program and a basis for comparison to values for other plants and to standard coefficients for unavoidable wastes presented later in this document.

(d) Production Scheduling. Production scheduling should be reviewed and, if not available, a chart developed indicating the time utilization of each piece of equipment in the plant. This will be useful later in evaluating the relationship of production scheduling to waste loads and in optimizing processing to minimize wastes.

(e) Maintenance Programs. The current maintenance program should be reviewed and determinations made as to the type and extent of preventive maintenance being utilized at the present time. A study should be made to make sure that the areas associated with major potential losses are in the program (such as air blow systems, pump seals, level controllers, etc.)

(f) Records. All plant records in respect to product loss reports and Market Report data and/or production loss reports should be reviewed and summarized.

Calculations should be made, where feasible, to express losses in terms that permit comparison to any coefficients available from prior waste water surveys (see Appendix 2 for appropriate calculations).

Initial Waste Survey

Following the collection of all available information, including location of drains, a preliminary plant survey should be made to establish an initial base line. The extent of the survey would depend upon prior data available. However, even if prior data is available from regulatory agencies, a survey is needed to provide a basis for further planning. If different departments are involved and different outfalls are involved, then we need to determine the feasibility of sampling each known outfall. The details of making a survey, flow measurement and sampling procedures are detailed in a later section.

Education of Management and Employees

Following the development of information on the plant, identification of high-loss areas, determination of degree of preventable loss and the economic impact of the product, water and energy losses, it's necessary to develop and put into application an educational program. This program is also detailed later.

Detailed and Continuing Plant Survey

To provide a basis for control evaluation, and specifically pinpointing the causes of both unavoidable and preventable wastes, a detailed survey is necessary.

At the same time, plans should be made for continued monitoring of wastes as a preferred method of evaluating real product losses and determining true yield of products (where yield equals product in minus product loss).

Implementation of Waste Control Procedures

This phase of the program is the most critical and requires the cooperation of all management and all plant operators. It will involve daily, weekly and periodic procedures well-outlined and determined in advance. Progress in control of wastes should be summarized weekly and made available to management and plant operators.

The waste control program requires a specific knowledge of the actual waste of product, water and energy that are occurring in the plant, and understanding of the design of the plant in respect to resource control and determination of the preventable waste loads. In initiating a program, major attention should be given to major areas of loss by unit process, and then attention given to these areas to specifically determine the exact nature or cause of the loss, followed by action to correct the situation.

C. MANAGEMENT CONTROL PROGRAM DEVELOPMENT

This section details the following waste management control program components:

1. Water and Waste Management Committee
2. Waste Control Manager
3. Educational Program
4. Initial Plant Survey

1. Water and Waste Management Committee

The Waste Control Manager must have the full cooperation of production, quality control, and the engineering departments. The first priority in this regard is that the General Manager or the Divisional Manager at the corporate level express his full support for the activities of the Waste Control Manager and support him in his projects to help reduce waste. Also, it is generally useful to form a waste management committee composed of at least the Waste Control Manager (who should act as chairman), the Quality Control Manager, the Chief Engineer, the Production Superintendent, and the Plant Manager as an ex officio member. Also included may be the Divisional Manager in a corporate setup and the Chief Financial Officer for the plant.

The waste control committee should serve to review the reports prepared by the Waste Control Supervisor. They should ask pertinent and relevant questions as to the validity of the data and what specific steps should be taken to eliminate problem areas specified. The committee should review any plans that the Waste Control Supervisor proposes to help eliminate waste. In doing this, the addition of the Chief Financial Officer for the plant would perhaps be beneficial for this committee. The combined expertise of these various individuals could thus effectively evaluate the success of any proposed production changes. The Chief Engineer can comment on their feasibility and compute accurate costs. The Quality Control Manager can express his views on the effect of the changes on the quality of products. The Production Superintendent would be the person responsible for implementing the changes and seeing that his personnel are adequately trained so that the proposed changes work as intended. The Plant Manager and/or Divisional Manager can lend their support in seeking approval at whatever level is necessary to secure the necessary funds. The role of the

Chief Financial Officer of the plant would be beneficial here in securing accurate costs of current production practices and estimating costs for production under the planned changes.

2. Waste Control Manager

Every dairy processing plant should have one person completely responsible for the water and waste program. The Water-Waste Manager must be management's representative responsible for the water-waste effort. The manager should have a technical background and an interest in his duties and an ability to work with people. He should be granted the latitude to develop the program and delegated the authority to implement his plans. He should report directly to the General Manager. Other duties should be kept to a minimum so that he can devote a majority of his time to water and waste problems.

During the preliminary phase of the program, he will have responsibility for the following:

1. The plant must be surveyed. Sketches, drawings, and maps should be detailed that indicate the size, capacity, and location of water lines, meters, sewer lines, junctions, manholes, and other parts of the system. Operating data should be compiled relating to water used, water wasted, as well as the BOD and flows to the main sewer.

2. The Water-Waste Manager, with the waste control committee, should examine the plant critically. Questions which should be answered include: Where is water used? Why is water used? How much is used? Where does waste originate? Why does waste occur? One effective method of evaluating a plant is to study photographs of the normal daily operations.

The Waste or Resource Control Manager is a key individual in the entire program of reducing losses in product, energy and water. If doing the right kind of job, his daily duties will require an absolute minimum of six hours per day in most plants. Generally, it is not advisable to make this assignment as an "add-on" job for one of the middle management people. This individual oversees all phases of the program and provides a direct liaison with the plant manager.

Continuing Responsibilities

In a total program, the Waste Control Manager would have the following responsibilities:

1. Coordinates the overall control program, reporting directly to the Plant Manager.

2. Develops short-term, medium-term and long-term

improvement programs for conservation of product, water and energy.

3. Serves as liaison with the public and regulatory agencies, keeping on top of new laws and regulations and representing the plant at hearings on local ordinances. Works with consulting engineers on areas such as new pretreatment requirements.

4. Serves as chairman of the plant Resource Control Committee, consisting of: Chief Maintenance Engineer, Production Manager, Quality Control Manager, Plant Manager (ex officio), Resources Control Manager (Chairman). May include also the Chief Financial Officer of the Plant and the Division Manager.

5. Supervises sampling and shipment of samples for analysis or directs analytical work in the plant, as appropriate. In some cases, he may perform the analyses.

6. Makes daily inspections of the plant to identify areas needing attention and reviews major control needs with the plant Waste Control Committee on a regular, planned basis.

7. Assists in development and operation of a preventive maintenance program to eliminate chronic problems.

8. Makes sure that product loss reports are routinely filled out and summarizes these reports on a daily basis. Where major losses are involved, immediate determination of the cause of the loss, and corrective measures need to be instituted. Daily summaries are forwarded to the Plant Manager and copies given to the Production Superintendent.

9. Conducts in-plant studies of high waste areas on a routine basis, determining amount, dollar value, causes and recommending corrective measures. In some cases, such studies will require an extended period of time.

10. Makes a regular study of water usage in high use areas, compares them to volume required for the operation, and makes recommendations for means to achieve water reduction.

11. Makes regular studies of energy uses in high use areas, compares same to energy required for the operation, and makes recommendations to achieve reduction in energy utilization.

12. Conducts special detailed studies as required to

achieve further conservation of product, water and energy.

13. Reconciles production and loss data, keeps records of loss, converts loss data into dollar values and gives first attention to losses of high dollar value.

14. Makes contacts with manufacturers of equipment used in the plant to get their assistance in determining where improvements can be made in process operations. In addition, gains assistance of manufacturers in respect to up-grading and improving preventive maintenance programs.

15. Serves as "in-house" instructor on waste control procedures, helps personnel recognize that while supervisors are responsible for the program, the operating personnel make it work.

16. Encourages the plant personnel to take a personal interest in conservation practices and obtains their cooperation in the control program. This will necessitate providing presentations at their level toward their specific interests. In many instances, the plant operators will have extremely valuable suggestions to be made in respect to the control program.

17. Facilitates communications between plant operators and management, since open communication channels are essential for successful operation of the control program.

18. Evaluates water, product and energy recovery alternatives and makes recommendations for improvement.

19. For long-term improvements requiring capital expenditures, conducts a cost-benefit analysis for all proposals. Consults with the chief financial officer in such studies.

20. Maintains all necessary records and develops a simple and meaningful summary report for presentation to the Plant Manager.

21. Develops an appropriate chart or graph to be posted, showing progress in resource control. Makes weekly revision of the material on this chart.

Record Keeping

Detailed records, oriented to milk, ice cream,and cottage cheese combination plants are shown in Appendix 3. The minimum record keeping should include the following:

1. Report of product losses through dumps, over-flows, leaks, spoiled product. These reports should be filled out by the operator, routed to the foreman, Production Supervisor, and then the Waste Control Manager. The Waste Control Manager will summarize these on a daily basis and route them to the Manager and to the Waste Control Committee at the regular meetings.

2. Maintenance request form to be initiated by the operators, filled out by their foremen, and routed to the Chief Engineer and Waste Control Manager. The Waste Control Manager will then assist the Chief Engineer in helping to develop a priority system for corrections of the problems and to follow-up on progress.

3. Supervision or determination, on a daily basis, of water flow, wastewater volume output, production figures, COD (or BOD) analysis, other analyses as required (pH, SS, N, etc.), and the preparation of a summary report of coefficients for total plant, ice cream, milk and cottage cheese.

4. Economic summary reports on water, energy, product losses, packaging material losses, and utility costs.

Interpretation

The Waste Control Manager will provide indication on a weekly and/or monthly basis, of the sewer charges, value of product losses, value of preventable losses of products, value of packaging material losses, labor losses associated with lost production, water and energy losses based on in-plant studies, and make recommendations to the Plant Manager and the Waste Control Committee.

Implementation

The recommendations made by the Plant Manager and by the Waste Control Committee should be implemented through the Waste Control Manager. The Waste Control Manager, in turn, will work through the appropriate management and supervisory personnel.

3. Educational Program

An educational program is essential to the success of any waste control program. The specific program to be developed will vary with the size and type of dairy plant operation. Generally, the program will have two emphases: (a) education and motivation of management through an understanding of the economic aspects of product, water and energy losses, and (b) education of plant operators through a better understanding of the social and environmental impact and significance of product, water and energy losses.

Getting started is the most difficult part for most plants with limited personnel trained in waste control. Generally, if the plant is developing its own in-house program, the Waste Control Manager needs to be educated first. He can then develop the essential teaching aids and carry out the program. Outside help can be utilized and many state universities have Extension personnel who can provide useful advice on setting up the program. Outside consultants can also be utilized.

A model, formalized program has been developed (2) that illustrates the type of educational program that has been successful in assisting waste reduction in several dairy plants in different areas of the country.

Top management is the first group that needs to be educated about plant wastes and the control program, because: 1) water conservation and waste reduction are important economic considerations, 2) management is often unaware of a problem, 3) management frequently does not have experience in solving water, waste and energy problems, and 4) much of the excess use of water and energy, and loss of product is due to careless or uninformed employees.

Water and waste management implies the supervision and control of water and wastes with executive ability and accountability. Management includes: 1) waste prevention, 2) waste recovery, 3) waste utilization, 4) waste disposal, 5) water conservation, 6) wastewater segregation, 7) wastewater pretreatment, 8) wastewater treatment (11) and 9) energy conservation.

Management must be made aware of the rapid rise in water and sewer charges which have increased rates 4 to 10-fold in some areas, and which shortly will reach all processors. The advantages of early action to offset the anticipated increases should be stressed. Carawan et al. (12) have shown the municipal discharge bill for a 500,000 pound per day plant exceeds $10,000/month when the rate schedule includes a surcharge. Management's profit motive should be cultivated by emphasizing that reductions of 50% in municipal bills are not uncommon with an effective water and waste program. Also, utilization of the average 4% unrecognized product loss may increase profit by 200%.

Plants are overlooking proven techniques for attacking water-waste problems because management has not recognized the economic consequences of inaction, or because the technical know-how is not readily available (3, 6, 8, 9,, 10, 12). Most managers need help in getting an effective program for reducing water initiated. In most plants, managements lack knowledge about BOD and wastewater flow, and employees are less informed (6, 3). However, public interest in environment and natural resources can be used to stimulate mangement and employees in achieving positive results in a water and waste management program.

The water and waste management educational program is structured around the following basic premises: 1) water should be managed as a raw material with real cost, 2) wastes in the effluent are primarily lost product, with a substantial value in addition to waste treatment or surcharge costs and 3) reduction in water and product losses also saves energy and labor.

The following suggested program to assist a dairy in initiating a water and wastewater management effort has been adapted from the program developed by Carawan and Jones(2), which was developed for use by an outside program coordinator, which could be either State Extension personnel or consultants.

The instruction is divided into four phases - 2 hours for management personnel, 2 hours with a Water-Waste Supervisor, 4 hours for employees, and a 2-hour follow-up evaluation session with the Water-Waste Supervisor and selected management personnel.

Management Phase

The management phase is scheduled for 2 hours. Selected visual aids that can be used in connection with this program are illustrated in Appendix 4. The specific steps to be taken are as follows:

1. Recognize the need for water and wastewater management effort, emphasizing cost and product losses.

2. Examine water and waste terminology - BOD, COD, TSS, surcharges, etc.

3. Explain key governmental regulations.

4. Explain wastewater management and how to start a wastewater management program. Tour facilities to explain waste control features applicable to the particlar plant.

5. Define the Water-Waste Supervisor's responsibilities and training.

6. Explain record keeping and basic calculations to convert raw data to the format best used by management.

7. Emphasize the importance of employee education in successful management.

8. Apply cost-benefit concepts to wastewater management.

During the management phase, attention should be focused on the need for a water-waste program and the action that can be taken by management to insure a successful effort. Also, management should be informed of the following specific benefits that can be achieved with the water conservation-waste program:

1. Expect plant to reduce water usage and water bills by 50%.

2. Expect plant to reduce its waste loads and related surcharge bills by more than 50%.

3. Expect plant to increase the effectiveness of its labor force by about 10%.

4. Expect a material savings in ingredients with an economic value greater than the saving in water and sewer bills.

5. Expect plant to reduce energy bills by from 5-10%.

6. Expect improved public relations as plant becomes a better corporate citizen.

7. Expect employees to be more knowledgeable about plant operation as a result of greater emphasis on water conservation and waste reduction.

8. Expect improved plant profits as product losses are reduced and as water and sewer charges decline.

The benefits will be accomplished by: (a) acquainting dairy plant personnel with water and waste terminology; (b) relating dairy waste losses to wastewater characteristics; (c) relating dairy waste to financial losses in dairy plants; (d) relating past surveys of individual dairy plants and national averages for water use and wastewater loads in dairy processing; and (e) developing and initiating action programs to reduce wastes within the plant.

Emphasis should be placed on the fact that waste in dairy wastewater is largely milk components and related ingredients (sugar, cocoa, non-fat dry milk, whey powder, buttermilk powder, fat, protein, carbohydrate, etc.) lost during various stages of processing. Milk has a BOD5 of approximately 100,000 mg/liter (22). Normal domestic wastewater has often been assumed to have a BOD5 of 250 mg/liter. Average dairy wastewaters have a BOD5 of 2500 mg/liter - about ten times as strong as domestic waste. If 90% of the BOD5 in dairy wastewater is product, as found by Harper et al.(22) and if the product is primarily milk with a BOD5 of 100,000 mg/liter, then one pound of BOD5 in the wastewater is equivalent to ten pounds of lost milk. Using this relationship, the loss of milk in processing can be estimated from wastewater analysis. Another approach, using COD analyses, is presented later in this Handbook. Product loss calculated from BOD5 is almost always greater than plant records indicate (4, 6). Harper et al. (22) found wastewater analyses revealed product losses averaged 5.24%, whereas plant records showed losses of 1.4%. The discrepancy is probably due to faulty fill control, unreported spillage, sampling errors, and inaccurate fat tests. The wastewater analysis is the most reliable measure of plant losses if samples are representative and analyses are properly conducted. There are too many ways for employees to compensate for losses in preparing loss records.

The relationship between water usage and plant wastes (product losses) as suggested by Carawan et al. (4) should be mentioned as a management tool. Simple water meter readings may be a fast and easy method of recognizing potential losses for immediate action.

Pictures of plant practices and waste samples taken on an hourly basis can be powerful visual aids to alert management to areas where more effective control can be achieved.

Waste Control Manager Phase

In many cases, the Waste Control Manager may have little prior direct experience with dairy food plant waste control and a program must be provided to:

1. Review information presented to management.
2. Outline Waste Control Manager's responsibilities.
3. Explain the necessity for adequate record keeping.

4. Point out key ways to keep management informed.

5. Emphasize the need for employee motivation on a continuing basis.

Resource materials which are available to inform and assist the Waste Control Manager should be recognized in this phase (see Appendix 8).

Employee Phase

A minimum of two 2-hour programs need to be developed for plant operators and maintenance personnel. The first program explains the nature of dairy plant wastes, their ecological impact, their origins and general control procedures. In some large plants the program may need to be put on for each different shift and under some circumstances this initial introduction may be presented in two 1-hour sessions. Both approaches have been effective, with the latter being more accepted by management in very large dairy plant operations. The second 2-hour program (or two 1-hour programs) is directed to detailed approaches for in-plant control measures for water, product, and energy savings. For multi-product or large dairy plants, the most effective approach is to develop separate programs for each department, such as:

-Maintenance

-Milk operations

-Cottage cheese operations

-Ice cream operations

Pictures and hours waste samples can also be used effectively with plant employees. In addition, detailed description of the equipment operation and control should be presented. Specific attention is directed to those features of the process or equipment that should be given special attention to avoid wastes. The relationship between equipment operation and maintenance is also stressed. Specific guidelines are presented on daily checks to be made to reduce excessive losses of product, water and energy that pertain to the specific department in the plant.

Environmental control features of waste control have more impact on plant operators than do economic factors and this can be utilized to advantage.

Follow-Up

A series of short follow-up programs with both management and employees on a period basis to indicate progress and to elicit suggestions can be higly beneficial. Evidence of continued interest on the part of management is essential.

Continued educational programs, especially of a one-on-one basis with interested employees can also be useful. In addition all new employees should be put through a waste control education program at the beginning of their employment. Prepared slide-tape programs of 15-30 minute duration can be used for this purpose.

4. Initial Plant Survey

Development of Complete Knowledge of Plant Water and Sewer System

A Waste Monitoring System should become an integral portion of the manufacturing process and be used as a measure of efficient operation. Once incorporated into the production system, it will be an invaluable check on the overall efficiency of plant operations as well as an aid in meeting legal requirements. The monitoring program will also provide basic data that will be valuable in the design of a wastewater treatment system to meet regulatory requirements.

To initiate any waste survey, the first step should be a complete survey of factory plant and processes. All stormwater and uncontaminated discharges within the factory should be isolated from the main effluent drain. Drainage plans, if available, should be thoroughly reviewed and each drain physically examined to determine its exact course and destination. The precise source at which each waste stream enters the main effluent drainage should be determined. Where plans of drainage and stormwater systems do not exist or are archaic, dye traces such as Rhodamine B or fluorescein should be utilized to confirm the existence of any cross-linkages in the drainage system. Dye should be dropped into each drainage point in the factory where it disappears beneath the floor and a second person will be required to check all the known outfalls for presence of such dye. In the establishment of a waste monitoring system, the logical place to start is at each main outfall, and samples collected for these place(s) will characterize the total plant effluent. At this stage, it may

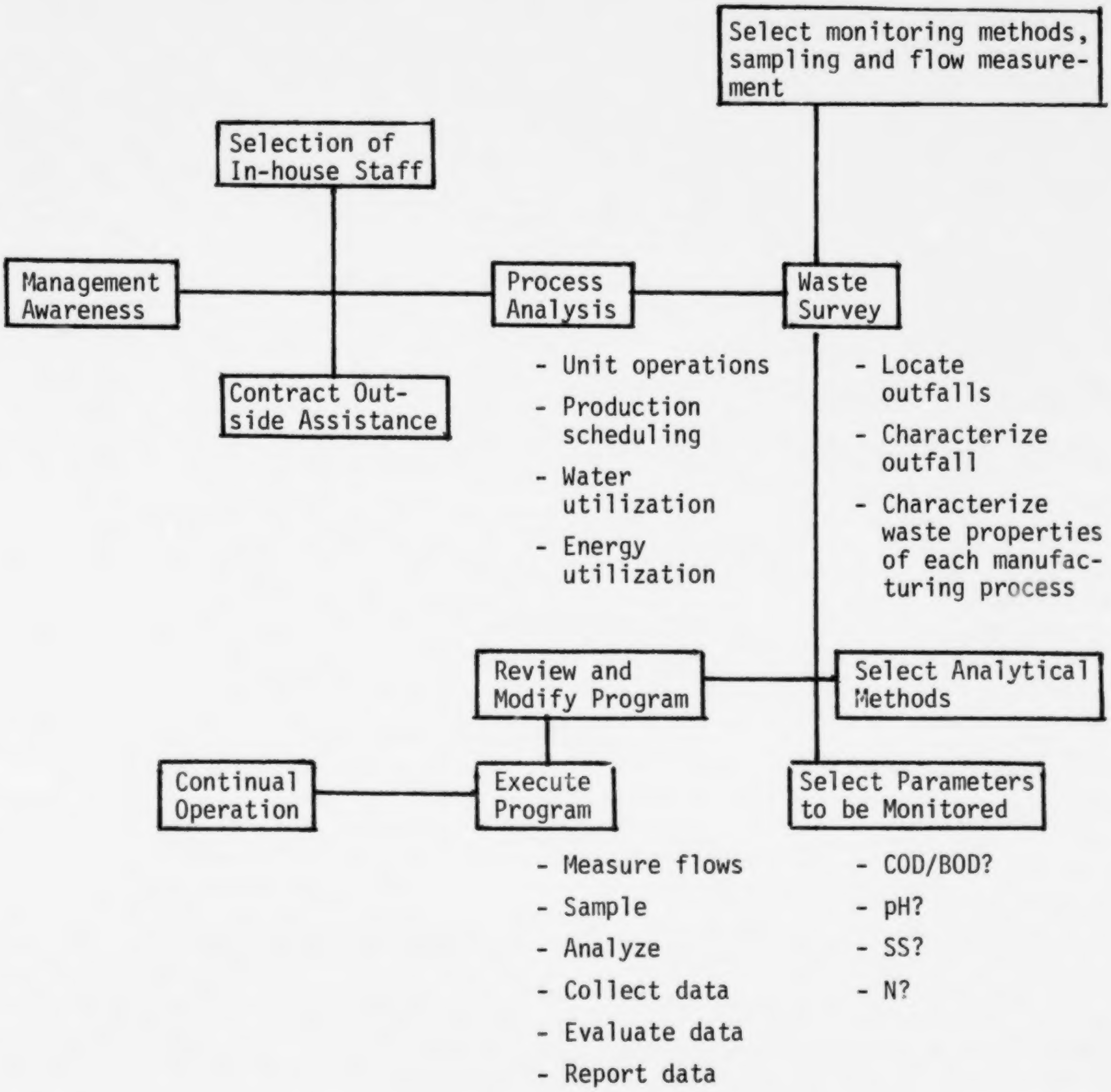
Select monitoring methods, sampling and flow measurement
Selection of In-house Staff
Management Awareness
Process Analysis
Waste Survey
Contract Outside Assistance
- Unit operations
- Production scheduling
- Water utilization
- Energy utilization
- Locate outfalls
- Characterize outfall
- Characterize waste properties of each manufacturing process
Review and Modify Program
Select Analytical Methods
Continual Operation
Execute Program
Select Parameters to be Monitored
- Measure flows
- Sample
- Analyze
- Collect data
- Evaluate data
- Report data
- COD/BOD?
- pH?
- SS?
- N?

Figure 1. Steps involved in establishing an effluent survey program.

not be necessary to characterize the smaller waste streams entering the main outfalls as data obtained on these points can be collected later, if required, by adaptation of the technique used for the main outfall from the plant.

In an old plant with multiple outfalls from the factory, a study should be made of the feasibility of developing a sampling station that would combine all of these to provide a single point for measuring the total waste from the plant.

The source of all clean water entering the plant should also be isolated and a detailed water line plan made. This is necessary for later isolation of individual departments for determining water use.

Flow Measurement

After selection of a suitable site for which access can be obtained to measure the wastewater flow, the next step will be the installation of flow monitoring equipment, which ideally should consist of some suitable flow measuring device and associated continuous recording equipmment. See the EPA Handbook for Monitoring Industrial Water (44) for more detailed information and calculations. The selection of suitable equipment is critical and must be based on careful observation of the flow characteristics before installation. Some assessment of maximum flow must be made in combination with the siting of the flow measurement device in such a manner as to insure strict adherence to all the hydraulic conditions peculiar to the particular device being used. Methods for rough estimations of flow can be summarized as follows:

(1) Bucket and stop-watch;

(2) Velocity area traverse method;

(3) Salt dilution;

(4) Calibration of pump rates;

(5) Californian pipe method; and

(6) Sewer size and slope method.

Open channel flow measurement by means of weirs or flumes is used where open channels are already in existence or where the requirements of pipe flow measurement cannot be met. The selection of the most suitable type of open channel flow measuring structure is dictated by maximum and minimum flows, site conditions and measurement requirements. Weirs of the

V-notch and rectangular types, because of their simplicity and economy of construction, are widely used in measuring industrial wastes. These weirs provide means of accurately measuring flows, providing certain precautions are taken. The V-notch weir provides a convenient method of measurement for discharges from 1 liter/s to 100 liter/s (~4-40 Gal/s). For smaller measurements, a half 90 degree V-notch may be used. If all precautions are taken, the equations available for the discharges from these weirs will give accuracies to within ± 2%.

Rectangular weirs provide a convenient and reliable method for the measurement of discharges greater than 20 liter/s (5 gal/sec) and can be constructed as either "suppressed" or "fully contracted" (terms which are used to describe how the weir is situated in relation to the channel sides).

Where weirs are used, special care must be made to insure that they are kept free of sediment and debris. In many dairy plants this requires daily cleaning.

A great deal of work has been carried out over the years on deriving formulae to calculate the discharge of water through flumes. Flumes are more easily adapted to the type of situations found in dairy factories, as there is minimal head loss for the same flow as compared with weirs, where the body of water must "free fall" into the tower water channel.

A flume is basically a streamline structure built into an open channel, forming a constriction through which the velocity flow is increased with a consequent fall in water level. When the constriction in the channel raises the water level upstream to such an extent that the discharge is independent of the downstream water level, then the velocity in the throat of the flume will be critical. This is the essential condition for the design of such a flume. A standing-wave flume can be located in any channel or rectangular, trapezoidal or semi-circular invert. The approach channel to the flume should be straight for a length equal to at least 10 times the water surface with a maximum flow. There are also a number of other geometric requirements for accurate flow measurement. The Parshall flume is an open constructed channel in which the differences in elevation of water flowing through are accurately translated into rate of flow. This type of flume has five very distinct advantages when compared with other flow measurement structures.

(a) The hydraulic head loss is very small, which makes the flume most useful when there is minimum allowable head loss in a pipe or channel;

(b) It is relatively insensitive to the velocity of approach of the liquid being measured;

(c) It has the capability of making good measurements,with up to 80% submergence from the downstream section;

(d) The velocity of flow through the flume is sufficiently great to eliminate sediment deposition within the structure during operation;

(e) It has the ability to function over a wide range of flow rates; and

(f) It can be used for recording small flows in large pipe which may be used for stormwater discharges.

The third main type of flume, Palmer-Bowlus, is available in a variety of forms for insertion into a channel invert. It works in a similar manner to other flumes, but has an advantage in that the height over the restriction does not need to be measured at an exact location, as is the case with the other flumes. For maximum accuracy in all placements, flumes should be designed for the flow rates which will exist in them and not for the channels into which they will fit.

For all the weirs and flumes outlined, the measurement of height of liquid above the "no flow" base line can be translated into instantaneous flow rate. This can be done in a number of ways, viz., by simply using a ruler and recording height and later calculating the flow rate each time the height is measured. A hook gauge overcomes the problem of menniscus, but again, it must be manually read. When flow rates are changing rapidly, as they do in dairy factory effluent drains, it is important that integration of flow rate be performed. There are a variety of commercially available height measuring devices, based on four main methods of height measurement, viz.:

(a) The bubbler tube method works on the principle that the back pressure developed by water height differences on the air bubbling from a tube below the surface can be translated through a diaphragm and a set of levers to give a height recording on chart paper. By using a system of cams, this height can be integrated according to the flow law for the weir or flume being used.

(b) A dipper probe which measures the height of liquid in the flume is the basis of the second type of equipment. A potentiometer records the distance traveled and gives a recording of the flow rate on a chart, which can be integrated electronically onto a digital readout. This system can be easily changed for different weirs or flumes.

(c) Ultrasonics is the basis of the third type of measurement and, as in the two above methods, a recording of flow rate and an integrated readout can also be obtained.

(d) Adaptation of traditional capacitance measuring techniques is the basis of the fourth type of flow measuring device. A sensing element is attached flush to the channel wall and connected to an electronic unit. The output of a low voltage radioxillator is applied to the sensing element. Changes in the channel depth cause minute currents to flow between the sensing element and ground. These changes are converted into flow units electronically and a wide variety of accessories and recording devices can be attached to the modified output signals.

Sampling

Of equal importance is the problem of obtaining a truly representative sample of the stream of effluent. The samples may be required not only for the 24-hour effluent loads, but to determine the peak load concentrations, the duration of peak loads and the occurrence of variation throughout the day. Assuming that a sample can be taken from the effluent drain which will be representative of the liquid in the weir or flume, there are a number of different ways of obtaining a 24-hour composite.

(a) A time-proportional method, which involves taking a sample at a set time interval, *e.g.*, every 1 minute, or every 30 minutes. The greater the frequency of sampling, the more representative will be the sample;

(b) A volume proportional method, in which a small sample is taken from the drain after a known volume, *e.g.*, 1000 liters (about 400 gallons), has passed through the flow measuring device.

(c) A flow proportional method, in which a sample is taken from the drain at a particular time but proportional to the flow passing the particular device at the time the sample is taken; and

(d) A combination method, in which the sample is taken proportional to both time and volume. Obtaining good results will depend upon certain details. Among these are the following:

(a) Insuring the sample that is taken is truly representative of the waste stream;

(b) Using proper sampling techniques; and

(c) Protecting the samples until they are analyzed.

The first of these requirements, obtaining a sample which is truly representative of the waste stream, may be the source of significant errors. This is especially apparent in the case of "grab" or non-composited samples. It must be remembered that waste flows can vary widely both in magnitude and composition over a 24-hour period. Also, composition can vary within a given stream at any single time due to a partial settling of suspended solids or the floating of light materials. Because of the lower velocities next to the walls of the flow channel, materials will tend to deposit in these areas. Samples should therefore be taken from the waste stream where the flow is well mixed. Since suitable points for sampling in sewer systems are limited, numerous ideal locations are not usual.

The usual method for accounting for variations in flow and waste constituents and minimizing the analytical efforts is by compositing the samples. Basically, sufficient samples should be taken so that, when mixed together (before analysis), the results which are obtained will be similar to taking a sample from a completely mixed tank which had collected all the flow from the stream in question. Greater accuracy is obtained if the amount of sample in the composite is taken in proportion to the flow. In general, the greater the frequency of samples taken for the composite, the more accurate the results.

Obtaining a representative sample should be of major concern in a monitoring program. A thorough analysis of the waste flows in the plant must be made and a responsible staff member should be assigned to insure that the samples taken are representative. As a general rule, closer attention must be given to waste sampling than in the sampling of a manufacturing process stream.

In many factories, the wastes are pumped from sumps within the factory before the liquid goes into settling tanks. Where a liquid is being pumped through a pipe, flow monitoring and sampling are often simplified, for in most cases the variations in pumping rate are minor and can either be calculated from the pump curves, or by calibrating pumps. Sampling under these systems involves using time-operated solenoid valves which open for a brief interval every minute or so. The timers should be interlocked with the pump motors so that samples are taken only when the effluent is being pumped.

Sample Preservation:

Samples should be analyzed as soon as possible after collection; however, in practice, immediate analysis is seldom feasible. Cognizance should be taken of certain time-dependent chemical changes that can occur in samples, such as:

(a) Metal cations may precipitate as hydroxides or form complexes.

(b) The valence state of the ions may change by oxidation or reduction.

(c) Metal cations may be absorbed on the surfaces of glass, plastic, or quartz containers.

Microbiological activity may also change the characteristics of the sample, as follows:

(a) Cell lysis may increase the BOD and COD.

(b) Cell productivity may change the BOD and COD.

(c) The organic nitrogen and organic phosphorus content may change.

Composite samples must be preserved in such a way that the characteristics to be measured do not change in quantity or quality. Special collection methods are sometimes required to avoid such changes. Recommended storage procedures are detailed in Table 1. For example, air should be excluded when samples are to be analyzed for O2, CO2, NH3, H2S, free chlorine, pH, hardness, SO2, NH4, FE++, acidity and alkalinity.

Table 1. Recommended Storage Procedure (43)*

Analysis	Sample Storage	
	Refrigeration at 4 degrees C	Frozen
Total solids	OK	OK
Suspended solids	Up to several days	NO
Volatile suspended solids	Up to several days	NO
COD	Up to several days	OK
BOD	Up to one day in composite sampling systems	**

*Ref. from Handbook.
**Lag develops; must use fresh sewage feed.

In practice, this means that air should not be permitted to enter the sample bottle and that the bottle should be completely filled. The pH should always be determine immediately after the sample has been collected and the oxygen content should be determined in situ or be fixed with manganese sulfate and potassium iodide as in the Winkler method.

Refrigerated sampling systems should be used for collection of 24-hour composite samples; only 6 hours at 50 degrees F is sufficient time to alter pH, microbial population and analytical results.

Freezing of dairy waste has been shown to be reliable for storage up to 30 days, provided the thawed sample is properly mixed. The thawed sample should be tempered to 40-43 degrees C (104-110 degrees F) and well mixed. For COD analyses, mixing for 1 minute in a Waring-type blender is advantageous to reduce variations in results.

Preservatives that do not influence the analysis should be added immediately after the sample is taken. Some authors have proposed alternative methods of preservation for certain constituents as follows:

(1) For nitrogen and phosphorus: add 1 ml H_2SO_4/1

(2) Samples with heavy metals should be filtered at the site of collection and acidified to a pH of about 3.5 with nitric acid

These and other recommended preservation methods are listed in Table 2.

Dairy Wastewaters

The storage of samples of dairy wastewaters can be successfully accomplished for certain tests. Generally, no more than one day's storage at 40 degrees F is recommended for BOD, COD, pH and microbial population as shown in Table 3.

Frozen samples of dairy wastewaters are satisfactory for BOD and COD and total solids. The high correlation coefficients shown in Table 4 confirm that 5 days' frozen storage is satisfactory.

Table 2. Sample Preservation (43)*

Maximum Parameter	Preservative	Holding Period
Acidity-alkalinity	Refrigeration at 4 degrees C	24 hours
Biochemical oxygen demand	Refrigeration at 4 degrees C	6 hours
Calcium	None required	7 days
Chemical oxygen demand	2 ml H_2SO_4 per liter	7 days
Chloride	None required	7 days
Color	Refrigeration at 4 degrees C	24 hours
Cyanide	NaOH to pH 10	24 hours
Dissolved oxygen	Determine on site	No holding
Fluoride	None required	7 days
Hardness	None required	7 days
Metals, total	5 ml HNO_3 per liter	6 months
Metals, dissolved	Filtrator: 3 ml 1:1 HNO_3 per liter	6 months
Nitrogen, ammonia	40 mg $HgCl_2$** per liter - 4 degrees C	7 days
Nitrogen, Kjeldahl	40 mg $HgCl_2$** per liter - 4 degrees C	Unstable
Nitrogen, nitrate-nitrogen	40 mg $HgCl_2$** per liter - 4 degrees C	7 days
Oil and grease	2 mg H_2SO_4 per liter - 4 degrees C	24 days
Organic carbon	2 mg H_2SO_4 per liter (pH 2)	7 days
pH	Determine on site	No holding
Phenolics	1.0 g $CuSO_4$/l + H_3PO_4 to pH 4.0 - 4 degrees C	24 hours
Phosphorous	40 mg $HgCl_2$* per liter - 4 degrees C	7 days
Solids	None available	7 days
Specific conductance	None required	7 days
Sulfate	Refrigeration at 4 degrees C	7 days
Sulfide	2 mg Zn acetate per liter	7 days
Threshold odor	2 ml Zn acetate per liter	7 days
Turbidity	None available	7 days

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*Ref. from EPA Handbook.

**Disposal of mercury-containing samples is a recognized problem; research investigations are under way to replace it as a preservative.

Table 3. Effect of 40 Degree F Storage on Dairy Wastewater Composite Samples

For One Day	For Three Days
No significant change in BOD COD SS pH Microbial population	Significant decrease in pH Carbohydrate COD BOD Significant increase in microbial population

Table 4. Frozen-Stored vs. Fresh BOD and COD Analyses of Dairy Wastes

	BOD5	COD
Fresh	2530	3541
Frozen & stored 5 days*	2580	3691
Correlation coefficient	0.95	0.91

*COD value valid up to 30 days of storage.

Analysis (43)

The main analyses required to assess the quantity of product in the liquid effluent are the determination of the Chemical Oxygen Demand (COD), lipid, total nitrogen and total solids (see Table 5). The most important of these is the COD. In addition the Biochemical Oxygen Demand (BOD), Suspended Solids (SS), and pH analyses will be required when the wastes are entering any system under the jurisdiction of regulatory agencies.

For any processing plant in which the effluent is of the same nature as the initial raw material, i.e., separation, powder drying, etc., the COD test is the only analysis necessary to determine the loss. The COD of the raw material must be known. In plants using a number of ingredients, such as ice cream, COD analyses need to be made on each ingredient.

In plants where the CIP system is under automated control the BOD/COD ratio will be relatively constant and COD may be used to predict the BOD of the effluent. In most dairy plants the BOD will be about 45% of the COD (BOD/COD ratio = .45). In a recent month's daily analysis survey of a multiproduct dairy, the BOD/COD ratio = .45 ± .03 standard deviation.

Table 5. The Main Tests, and Their Areas of Application Used to Monitor the Losses of Product to the Liquid Effluent.

Raw product Processed	Type of Process	Nature of Effluent Constituents	Analytical Method to Assess Losses
Whole milk or skim milk	Tank truck receiving, separating, pasteurizing, evaporating, and drying	Whole or skim milk	Chemical oxygen demand (COD)
Cream	Butter making	Butter(fat) Buttermilk	Fat Protein
Skimmilk	Cottage cheese	Casein	COD casein fines protein
		Whey	
By-products from:			
Cream processing	Buttermilk powder	Buttermilk	COD
Skimmilk processing	Whey powder	Whey	COD
Ice cream	Blending, pasteurizing, freezing	Sugar, milk solids, (fat)	COD Fat

Use of Effluent Data to Compute Product Losses

In a manufacturing plant with no product losses from any area, the quantity of material delivered to the plant equals the quantity leaving the plant.

However, in any manufacturing process there are inherent losses. In a fluid milk dairy these will include packaging losses due to overweight packs, material used for samples and all losses of liquid and semi-solids associated with operation of the manufacturing equipment, many of which are avoidable.

The traditional method by which dairy plants determine plant productivity and yield information is to compare the quantities of product packed with the quantities credited to the plant as raw materials. Due to the inaccuracies of this determination on a day-to-day basis, it has become necessary for management to know quickly when major losses have occurred to develop another means of arriving at the true yield information. With the increasing attention being paid all over the world to environmental control and the reduction of all forms of pollution, equipment has been developed to enable accurate measurement and sampling of liquid waste streams and it is from these developments that another method of determining yields has developed. This will never supercede the traditional methods which must continue to be used for accounting purposes.

An example is used of a multiproduct dairy, utilizing where possible, the latest in sophisticated techniques to obtain values for raw materials received and products manufactured.

The yield of material for the whole plant is then calculated from the sum of the products, whether by weight, milkfat content, total solids, chemical oxygen demand, or nitrogen, divided by the sum of the raw materials entering the plant and measured by any of the above parameters.

$$\text{i.e., Yield \%} = \text{Out/In} \times (100/1)$$

If the measurements of material entering or leaving the plant (or still in transit through the plant, when a day or period is considered to be over, e.g., cream held in a silo for the next day's manufacture), is subject to any errors, then the yield figure also will be in error.

For the sample dairy, let us consider the possible areas of measurement error, based throughout on total solids measurement, a measurement with a low degree of inaccuracy. These areas are listed in Table 6.

Table 6. Areas of Measurement Error

A. RAW MATERIALS

(i)	Weighbridge error (0.1% each time)	± 0.2%
	Sampling error	± 0.1%
	Total solids measurement error	± 0.25%
	Then raw milk solids errors are	± 0.55%
(ii)	Condensed milk (assume 5% of total)	
	Weighbridge error	± 0.2%
	Sampling error	± 0.1%
	Total solids measurement error	± 0.25%
	Then condensed milk solids errors are	± 0.55%
	but at 5% level of usage	± 0.03%
(iii)	Whey and skimmilk and sugar powders	
	Bag weight errors	± 0.2%
	Determination of moisture content	± 0.12%
	Then powder solids errors are	± 0.32%
	and if used at 10% of milk solids	± 0.03%
(iv)	Miscellaneous materials	
	Usage levels are relatively low and errors can be ignored.	
	Total measurement error of raw materials (assuming best possible measurements)	± 0.61%

B. PRODUCT

(i)	Fluid milk (50% of plant production)	
	Weight measurement of containers (gallon) (90%)	± 0.52%
	Weight measurement of containers (smaller) (10%)	± 1.2%
	Total solids measurement errors	± 0.24%
	Thus fluid milk errors are	± 0.78%
(ii)	Ice cream (40% of plant production)	
	Weight measurement of packs	± 0.4%
	Total solids measurement errors	± 0.25%
	Ice cream errors	± 0.65%
(iii)	Cottage cheese, etc. (10% of plant production)	
	Weight measurement errors	± 1%
	Total solids measurements	± 0.5%
	Total errors in cheese, etc.	± 1.5%

The weighted, average measurement errors for the products manufactured are	± 0.80%

Yield Calculation

If yield is determined by products/raw materials, then assuming a 2% loss of solids to the liquid effluent and overweight packaging, the yield calculation becomes:

(Solids packed)/(Solids in raw material) = 98/100 or 98%

However, if the errors in the measurements are included, the equation becomes:

(Solids packed)/(Solids in raw material) = (98 ± 0.8)/(100 ± 0.6)

As a guide to management of any day-to-day losses occurring in the plant, this method of determining yield is limited. Further problems arise when quantities of material are held over in a semi-processed state until the processing day.

Yield Determinations by Loss Measurement Technique

The yield equation can be rewritten

Yield % = [(Product out)/(Raw materials in)] x (100/1)

But product out must equal the raw materials in minus the losses, or,

Yield % = [(Raw material in - losses)/(Raw material in)] x (100/1)

Alternatively, this can be written as

[(Product in)/(Product out + losses)] x (100/1)

or, from raw materials,

Yield % = [1 - (losses)/(raw material)] x (100/1)

or, from product,

Yield % = [1 - (losses)/(product out + losses)] x (100/1)

Using the equation for the raw materials, and assuming,

(a) losses can only be measured accurately to within 5%;

(b) raw materials measurement errors are as for the calculations used previously; and

(c) a plant whose true yield is 98%.

Yield calculation becomes

$$[1 - (2/100)] \times (100/1) = 98\%$$

and with measurement errors included

$$[1 - (2 \pm 5\%)/(100 \pm 0.6\%)] \times (100/1)$$

or a possible range from

$$[1 - (1.9/100)] \times (100/1) \quad \text{to} \quad [1 - (2.1/99.4)] \times (100/1)$$

i.e., from 97.89 to 98.11%.

This is almost an order of magnitude better for the prediction of day-to-day yield analysis for management control than the traditional method.

This has been an example for a simple case (total solids) in a complex multiproduct plant, but the same reasoning holds true for all instances, with slight modifications required for the determination of the raw material, products, and losses.

The calculations necessary to use COD analysis of waste and raw materials to calculate yield are in Appendix 2.

In all cases where the authors have applied these procedures to dairy plants (within the United States and in New Zealand), the loss based on wastewater analysis exceeded the loss calculated from production figures for the same time period. Attempts to pinpoint the precise reasons for this have not been successful because of the large number of contributing errors. However, unreported spillage, use of standard factors, use of production schedule values as quantity processed, use of volume measurements, air incorporation, and filling practices, can all contribute to the problem.

The authors are convinced of the validity of using waste analysis as a valid basis upon which to develop a resource control program.

D. WATER AND WASTE CONTROL

1. Determination of Achievable Goals

This section of the Handbook provides background information upon which to make judgment of the degree of preventable and unavoidable wastes in a particular plant situation. Specifically covered are detailed composition of dairy products (Table 7), whey conversion values (Table 8), the COD and BOD relationship for these products, sources of waste, and achievable water and waste coefficients for unit processes and for different types of dairy plant operations.

For purposes of calculations, it is frequently useful to know the BOD and/or COD values for various constituents for dairy foods. Average values for various milk constituents are given in Table 9. Average values in pounds of BOD/pound of component were 0.65, 0.9, and 1.3 for lactose, milk fat and milk protein, respectively. Table 10 gives BOD and COD values for a number of common dairy products. Primarily because of fat, BOD/COD ratios are variable and COD provides a better index of product losses than BOD for high fat products.

Relationship of Product Viscosity to BOD

Different products differ markedly in their viscosity and limited data is available to interrelate the product residual surfaces. Table 11 provides BOD conversion factors to interrelate different products. Table 12 gives the relationship between viscosity of the product and the loss for various dairy products and conversion factors to estimate expected loss of different types of dairy products on equipment surfaces. This conversion system is to provide a basis for calculation of unit process coefficients for different types of products by multiplying the coefficient for milk times the BOD conversion H factor.

Table 7 - Average Composition of Milk and Milk Products (100 g)

Product	Fat (g)	Protein (g)	Lactose (g)	Lactic Acid (g)	Added Organic Ingred.	Total Organic Solids	Ca (mg)	P (mg)	Cl (mg)	S (mg)	Total Ash (g)	Viscosity (c.p. at 20°C)
Skim Milk	0.08	3.5	5.0	--	--	8.56	121	95	100	17	0.7	1.4
2% Milk	2.0	4.2	6.0	--	--	12.2	143	112	115	20	0.8	2.4
Whole Milk	3.0	3.5	4.9	--	--	13.1	118	93	102	19	0.7	2.2
Half & Half	11.7	3.2	4.6	--	--	19.5	108	85	90	16	0.6	7.5
Coffee Cream	18.0	3.0	4.3	--	--	25.3	102	80	73	12	0.6	15.0
Heavy Cream	40.0	2.2	3.1	--	--	45.3	75	59	38	9	0.4	25.2
Choc. Milk	3.5	3.4	5.0	--	Sucrose, 6% Choc.Solids, 1%	18.5	111	94	100	19	0.7	75
Churned Buttermilk	0.3	3.0	4.6	0.1	--	8.0	121	95	103	15	0.8	1.5
Cultured Buttermilk	0.1	3.6	4.3	0.8	--	10	121	95	105	17	0.7	500
Sour Cream	18	3.0	3.6	0.75	--	24.6	102	80	73	12	0.6	10,000
Yoghurt	3.0	3.5	4.0	1.1	Fruits, Flavors	10.5	143	112	105	19	0.7	9,000
Evaporated Milk	8.0	7.0	9.7	--	--	27	757	205	210	39	1.6	30
Ice Cream	10.0	4.5	6.8	--	Sugar, 15%	41.3	146	115	104	20	0.9	35.0
Whey (sweet)	0.3	0.9	4.9	0.2	--	6.3	51	53	95	8	0.6	1.4
Cottage Cheese Whey (acid)	0.08	0.9	4.4	0.7	--	6.1	96	76	95	8	0.8	1.3

Table 8 - Whey -- Cheese Conversion Factors

Cheese	Milk		Yield*				Whey Solids		Fluid Whey	
			Curd		Whey					
	Type	% B.F.	Lb.	% H_2O	Lb.	% Solids	Per 1 lb. Curd	Per 1 lb. Cheese	Per 1 lb. Curd	Per 1 lb. Cheese
Cheddar	Whole	3.5	9-1/2	35	90-1/2	6-1/2	0.618	0.618	9.56	9.56
Cottage										
Conventional	Skim	0.1	15	80	72	6.1	0.293	0.202	4.80	3.37
Creamed	Cream	10.5	33	54-1/2	67	6.0	--	0.122	--	1.99
Parmesan	Skim	1.8	8-3/4	41	91-1/4	6-1/2	0.678	--	10.42	--
	Skim	1.8	7-1/2	32	--	--	--	0.79	--	12.1
	Skim	1.8	6-1/4	17	--	--	--	0.95	--	14.6
Swiss	Whole	2.8	8	38	92	6-1/2	0.746	0.746	11.50	11.50

*Yield based on 100 lb. milk with fat content shown under milk column.

Table 9. Reported BOD Values for Various Milk Constituents and Related Constituents

Constituent	Average Pound BOD5/Pound Component
Lactose	0.65
Glucose	0.66
Lactic acid	0.63
Milk fat	0.89
Glycerol	0.75
Butyric acid	0.75
Sodium butyrate	0.41
Palmitic acid	1.07
Sodium palmitate	0.70
Stearic acid	0.80
Sodium stearate	1.20
Milk proteins	1.03
Casein	1.04
Hydrocolloids	
Sodium alginate	0.36
Carboxymethyl-cellulose	0.30
Surfactants	
Soap	1.43
Dreft	0.49
Br. ch. alkyl benzyl sulfonate	0.02
Tween 80	0.35

Table 10. Literature Values for BOD of Various Dairy Products*

Product	Percent Organic Solids	BOD5 Average	BOD5/ Organic Solids	COD	BOD/COD ratios
	(%)	(mg/l)	(lb/lb)	(mg/l)	
Skimmilk	8.2	67,000	.82	103,000	.65
Whole milk	11.7	104,600	.88	173,000	.60
Half & Half	19.5	175,000	.88	365,000	.48
Cheese dressing	2.0	150,000	.86	312,000	.48
Yoghurt	10.5	98,000	--	270,000	.36
Ice milk	32.5	218,500	--	400,000	.55
2% milk	12.2	90,500	--	146,000	.62
Cream - 18%	29.3	215,000	--	440,000	.49
Cream - 40%	44.9	399,000	.88	2,100,000	.19
Concentrated Skimmilk (2:1)	26.2	208,000	.79	346,000	.60
Ice cream Mix (10% fat)	34.0	292,000	.85	540,000	.54
Churned Buttermilk	6.8	51,600	.75	86,000	.59
Whey (sweet)	6.0	33,900	.56	61,600	.55
Whey (acid)	5.8	32,000	.53	70,000	.54

*Cited values will change with changes in composition.

Table 11. BOD5 Conversion Factor (H Factor) (14)

Product	Code	BOD5 HFactor*
Skim	SK,SM	.76
Low fat	LF	.86
Homogenized	HO	.95
Half & Half	HH	1.53
Chocolate	CH	1.33
Buttermilk	BM	.98
Sour cream	SC	2.35
Drinks	FA	.53
Orange juice	OJ	.73
Cottage cheese	CC	1.98
Dressing	DS	1.78
Curd	CD	1.99
Ice cream	IC	2.64
Whey (no fines)	WH	.38
Returns	RT	.92
High solids recovery	RH	.50
Receipts (whole milk)	RM	1.00
Cream	CM	4.03
Liquid cane	LS	4.43
Corn syrup	LC	5.13
Condensed skim	CS	2.12

*BOD5 H Factor = (BOD5 Product)/(BOD5 Whole Milk)

BOD5 Ratio H Factor = (Residual BOD5 of Product)/(Residual BOD5 of Whole Product)

BOD of Product = H Factor x 100,000 mg/l
= H Factor x .100 pounds BOD/pound of product

Table 12. Relationship of Product Viscosity, Product Loss and Residual BOD5 for Dairy Products*

Product	Viscosity	Product Remaining on Surface	Residual BOD5 (BOD5/ Product)	RH Factor***
	(cp)	(%)	(#/1000 #)	
Skimmilk	1.4	0.005	0.072	0.3
Low fat	1.6	0.14**	0.17**	0.6
Whole milk	2.0	0.26	0.26	1.0
Chocolate milk	21.0	0.47	0.69	2.6
Half & Half	15.6	0.39	0.61	2.4
Cream, 40% BF	91.0	0.95	3.80	15.0
Cultured buttermilk	500.0	2.30	1.47	5.6
Sour cream	9000.0	3.50	7.00	27.0
Yoghurt	1000.0	2.80	2.1	8.1
Ice cream mix	121.0	0.86	3.4	13.0
Condensed skim	21.0	0.50**	1.05**	4.0
Whey (no fines)	1.0	--	0.072	0.3

*Harper, et al. (22)
**Estimated by Carawan (14)
***RH Factor = (Residual BOD5 of Product)/(Residual BOD of Whole Milk)

Sources of Dairy Food Plants' Wastes

Determination of the significant sources of dairy food plant wastes requires an understanding of the processing of dairy foods, the various unit operations and their potential role as sources of wastewater, milk solids and refractory compounds. Detailed information on sources of dairy food plant wastes are found in references cited in Appendix 8 (11, 22, 23, 50 and 56). Flow Diagrams of various unit processes for processing milk into its various products, waste generating processes and the general nature of the waste for different dairy plant operations are presented in Flow Diagrams 1-16.

The unavoidable waste generating processes of major significance include:

- washing, cleaning and sanitizing of all pipe lines, pumps, processing equipment, tanks, tank trucks, and filling machines;

- start-up, product change-over and shut-down of HTST and UHT pasteurizers; and

- lubrication of casers, stackers and conveyors.

In the Flow Diagrams, the piping associated with a unit process is considered to be an integral part of that operation. Thus, the waste generating process of tank truck washing would include all pumps and piping in the receiving room; cleaning of raw storage tanks would include the associated raw milk pumps, valves and lines.

Spills and leaks from pipe line joints, valves and pumps have not been included as waste generating processes in any of the Flow Diagrams. Although these sources are significant to varying degrees in different dairy food plants, they are inherently controllable through the application of good management practices. Generally, the nature of the wastes generated by the various processes is similar; including milk solids in some form, other ingredients such as sugar, cocoa, etc., plus detergents and sanitizers in most product processing steps and these same materials plus lubricants are generated in packaging and distribution operations. The significance of various waste generating processes to the total waste load of the dairy food plant wastewater is a characteristic of the individual process and will be discussed in a later section of this report.

Fluid Milk Operations. Flow Diagrams 1-5 are for fluid milk operations, their subprocesses and various alternative processes for certain by-products. Milk receiving and storage are common to all of the unit operations and their subprocesses. Other unit operations that apply to all dairy food plants include the utilization of centrifugal machines (for clarifying, separating and/or standardizing), pasteurized product, and filling and distribution. In market milk processing the significant waste generating processes include sludge centrifugal machines, tank washing and sanitizing, high-temperature short-time presses, cleaning and sanitizing of processing vats and lines, cleaning and sanitizing of storage vats, drips, broken packages, damaged packages,

PLANT PROCESS	WASTE GENERATING PROCESS	NATURE OF WASTE
Milk receiving	Tank truck washing	Milk solids & detergent
Clarifying and/or standardizing	Sludge from centrifugal machine	Milk solids high in protein & cells
Storage of raw milk	Tank washing and sanitizing	Milk solids & detergent & sanitizer
HTST pasteurization, homogenization	HTST start-up & product change over, cleaning	Milk solids & detergent & sanitizer
Standardizing, separating, cooling	Sludge from separator	Milk solids high in protein and cells
Vat processing cream	Cleaning and sanitizing	Milk solids & detergent & sanitizer
Storage of milk & cream	Cleaning and sanitizing	Milk solids & detergent & sanitizer
Filling and transfer to cooler	Drips, broken packages conveyor lubrication cleaning	Milk solids & detergent & sanitizer & lubricant
Cold storage and distributor	Broken packages conveyor lubrication returns	Milk solids & detergent & sanitizer & lubricant

Flow Diagram 1 -- Market Milk

PLANT PROCESS	WASTE GENERATING PROCESS	NATURE OF WASTE
Milk from raw storage tanks	Tank and line washing and sanitizing	Milk solids & detergent & sanitizer
Separation	Sludge from separator cleaning	High protein milk wastes, detergent & sanitizer
Cream storage	Cleaning cream lines & storage tanks sanitizer	Cream & detergents & sanitizers
Skim milk storage	Cleaning skim & storage tank & sanitizing	Skim milk & detergents & sanitizer
Special milks 2% fortified chocolate, half & half	Clean lines & storage tanks sanitizers	Special milk & wastes & detergents & sanitizers
Vat pasteurization	Cleaning & sanitizing vat	Special milks & detergents & sanitizer
Storage of special milks	Cleaning storage tank & sanitizing	Special milks & detergents & sanitizer
Filling, casing, stacking & conveying	Cleaning filters, machine jamming, broken packages, conveying + transfer	Special milks & detergents & lubricants
Special milks & Cold storage	Broken packages	lubricants
Distribution	Returns	Special milks

Flow Diagram 2. Market Milk - Subprocess - Skim Milk, Creams and Special Milks by Batch Processing - Alternate 1

PLANT PROCESS	WASTE GENERATING PROCESS	NATURE OF WASTE
Milk from raw storage tank	Rinsing & cleaning tank trucks	Milk wastes & detergent
Separation	Sludge from separator, cleaning & sanitizing	High protein cellular waste & detergent & sanitizers
Cream storage	Cleaning storage tank, sanitizing	Cream wastes & detergents & sanitizers
Skim storage	Cleaning storage tanks, sanitizing	Skim Milk wastes & detergents & sanitizers
Metered blending to make all fluid by-products continually	Cleaning lines & equipment, sanitizing	Milk wastes & detergents & sanitizers
HTST pasteurization	HTST start-up & shut-down, cleaning & sanitizing	Milk wastes & detergents & sanitizers
Storage	Cleaning Storage tanks sanitizers	Milk wastes & detergents & sanitizers
Filling and transfer	Jamming of fillers, broken packages, cleaning & sanitizing	Milk wastes & detergent & sanitizers & lubricant
Cold storage & Distribution	Broken packages & returns	Milk wastes & lubricants

Flow Diagram 3. Market Milk - Subprocess - Skim Milk - Creams and Special Milks by Continuous Process - Alternate 2.

PLANT PROCESS	WASTE GENERATING PROCESS	NATURE OF WASTE
Milk from raw storage	Cleaning & sanitizing tank & lines	Milk wastes & detergents & sanitizers
HTST pasteurization (homogenization)	HTST pasteurizer start-up,shut-down & cleaning & sanitation	Milk wastes & detergents & sanitizers
Separating	Sludge from separation	High protein milk waste & detergents & sanitizers
Skim	Cleaning skim lines	Skim milk & detergents & sanitizers
Cream	Cleaning cream lines	Cream & detergents & sanitizers
Continuous blending	Cleaning product lines	Special milks & detergents & sanitizers
Storage of special milks	Cleaning storage tanks	Special milks & detergents & sanitizers
Filling, casing, stacking conveyor	Cleaning filters, machine jamming, broken packages from transfer & conveying	Special milks & detergents & sanitizers
Cold storage	Broken packages	Special milks & lubricants
Distribution	Returns	Special milks

Flow Diagram 4. Market Milk - Subprocess - Skim Milk - Creams and Special Milks by Continuous Process - Alternate 3.

PLANT PROCESS	WASTE GENERATING PROCESS	NATURE OF WASTE
Skim milk from storage tank	Storage tank cleaning, sanitizing	Milk wastes & detergent & sanitizer
Cream from storage tank	Storage tank cleaning, sanitizing	Milk wastes & detergent & sanitizer
Blended to desired fat test	Line and tank cleaning, sanitizing	Milk wastes & detergent & sanitizer
HTST or vat pasteurization (190 F, 3 min. or 30 min. mix) hold homogenization	HTST start-up & shut-down, cleaning	Milk wastes & detergent & sanitizer
Starter manufacture	Starter tank cleaning, sanitizing	Starter wastes (pH 4.6) & detergent & sanitizer
Buttermilk manufacture	Buttermilk lines & tank cleaning, sanitizing	Buttermilk (pH 4.7) & detergent & sanitizer
Sour cream vats	Sour cream lines & tank cleaning, sanitizing	Sour cream (pH 4.5) & detergent & sanitizer
Yogurt manufacturing, fruit blending	Yogurt lines & tank cleaning, sanitizing	Yogurt (pH 4.5) & detergent & sanitizer
Filling	Filler cleaning, machine jams, overfilling	Acid milk or cream waste & detergent & sanitizer
Storage and Distribution	Broken packages	Acid milk or cream wastes

Flow Diagram 5. Market Milk - Subprocess - Buttermilk, Sour Cream and Yogurt.

cleaning of fillers, conveyor lubrication and cleaning; broken packages, conveyor lubrication and returns constitute waste generating steps in cold storage and distributions.

Butter. Flow Diagrams 6 and 7 give the outlines of the churn and the continuous method for butter operation. The continuous process materially reduces potential waste strength by eliminating the buttermilk production and the washing steps. Disposition of skimmilk and buttermilk for food use may be accomplished by the use of a drying operation in conjunction with butter operation, or these materials may be shipped to another dairy food plant by tank truck.

Cheese. Unit process operations, waste generating processes and the nature of wastes for cottage cheese, Cheddar cheese, Swiss cheese and Italian cheese operations are outlined in Flow Diagrams 8-11 to represent different types of cheese manufacturing processes.

The most visible source of waste in the dairy industry is in the whey resulting from the various cheese operations. There has been an increasing trend in the industry to exclude all whey from waste treatment and to use it for feed or food. Where whey is to be shipped to another plant for processing into a concentrated form for food use, the cheese factory has had to install (or utilize) sanitary storage tanks and cooling equipment to prevent the outgrowth of food infections or poisoning organisms prior to shipment. Washing and cleaning of such equipment would constitute another waste generating step not shown in Flow Diagrams.

The cottage cheese operation differs from the other cheese processing in that it produces a whey of low pH (4.5 - 4.7) and utilizes washwater (equal to twice the whey volume) to remove residual whey, lactose and lactic acid from the curd. Cottage cheese curd is more fragile than rennet curd which is used for the other three types of cheese. Thus, the whey and washwater may contain appreciable fine curd particles ("fines"). The amount of "fines" in the washwater is increased if mechanical washing (such as "Curd-O-Matic") processes are used. Complete draining of the curd, a "pre-wash" of 5% of the whey volume with draining and a combination of this material with the whey to be sold for feed or food use or use of whey to cool the curd can decrease the BOD of the washwater by 20-40%.

In Cheddar cheese, the whey draining during cheddaring (matting of the curd) and pressing should be collected and combined with the whey.

In Swiss cheese manufacture, appreciable whey is lost in the transfer of the curd from the vat to the draining.

UNIT PLANT PROCESS	WASTE GENERATING PROCESS	NATURE OF WASTE
Milk receiving	Cleaning tank trucks	Milk and/or cream wastes & detergent
Separation	Sludge Removal	High protein cellular matter & detergent & sanitizer
Skim storage	Cleaning lines & storage tanks, sanitizing	Milk wastes & detergent & sanitizer
Cream storage	Cleaning lines & storage tanks, sanitizing	Cream wastes & detergent & sanitizer
HTST pasteurization, phase inversion, & oil storage	HTST start-up, shut-down & cleaning	Cream wastes & detergent & sanitizer
Standardization	Cleaning equipment	Butter oil, milk solids
Continuous churning	Cleaning lines & equipment, sanitizing	Butterfat & detergent & sanitizer
Printing & packaging	Packaging losses, cleaning packaging equipment	Butterfat & detergent & sanitizer
Storage & Distribution	Damaged packages	Butter, fat

Flow Diagram 6. Butter -Continuous Churn Process

PLANT PROCESS	WASTE GENERATING PROCESS	NATURE OF WASTE
Milk receiving	Cleaning tank trucks	Milk and/or cream wastes & detergent
Separation	Sludge removal	High protein cellular matter & detergent & sanitizer
Skim storage shipped out	Cleaning lines & storage tanks, sanitizing	Milk wastes & detergent & sanitizer
Cream storage	Cleaning lines & storage tanks, sanitizing	Cream wastes & detergent & sanitizer
Vat Pasteurization	Cleaning pasteurizer, sanitizing	Cream wastes & detergent & sanitizer
HTST pasteurization	HTST start-up, shut-down & cleaning	Cream wastes & detergent & sanitizer
Churning	Buttermilk	Buttermilk not excluded from drain & residual in lines & equipment
Washing butter	Wash water containing buttermilk	Dilute buttermilk wastes
Printing & packaging	Packaging losses, cleaning packaging equipment	Butterfat & detergent & sanitizer
Storage & Distribution	Damaged packages	Butter, fat

Flow Diagram 7. Butter - Churn Process.

PLANT PROCESSES	WASTE GENERATING PROCESS	NATURE OF WASTE
Skim milk from separator sanitizer	Cleaning lines & sanitizing	Skim milk waste & detergent &
HTST pasteurization	HTST start-up, shut-down, cleaning & sanitizing	Milk waste & detergent & sanitizer
Starter manufacture	Cleaning starter lines & tank	Starter (pH 4.6) & & detergents & sanitizers
Setting, cutting cooking, draining	Whey draining	Whey not excluded from drain & fine curd particles
Washing - 3 times	Wash water draining	Diluted whey = 0.5-1.0 of original whey solids & fine curd particles
Cooling	Curd transfer & cheese vat cleaning, sanitizing	Curd particles & detergents & sanitizer
Cream from pasteurized storage	Cleaning cream lines & storage tanks	Cream waste & detergents & sanitizer
Creaming	Cleaning creaming tank or vat curd transfer	Curd & creaming mixture & detergents & sanitizer
Packaging	Filling machine jamming, overfill, cleaning, sanitizing	Cottage cheese curd & cream & detergents & sanitizer
Storage & Distribution	Broken packages, returns	Cottage cheese cream

Flow Diagram 8. Cottage Cheese.

PLANT PROCESSES	WASTE GENERATING PROCESS	NATURE OF WASTE
Milk receiving	Tank truck or can washing	Milk wastes & detergents & sanitizers
Milk storage & standardization	Storage lines & equipment cleaning sludge from separation	Milk wastes & detergents & sanitizers
Cream storage	Emptying & cleaning & sanitizing	Cream wastes & detergents & sanitizers
Starter manufacture (skim)	Starter tank & line cleaning & sanitizing	Starter (4.6 pH) from cleaning & detergents & sanitizer
Curd making, cutting, cooking & whey manufacturing	Whey draining	Any whey not excluded from drain & residual whey & curd & detergents & sanitizers
Cheddaring, milking, salting	Whey drained vat cleaning & sanitizing	Whey, salt & curd & detergents & sanitizers
Washed curd processing, salting	Curd washing, vat cleaning	Diluted whey curd & detergents & sanitizers
Hooping, forming, pressing	Pressing, trimming	Whey curd & detergents & sanitizer
Aging	Washing cheese surface	Organic matter from washings
Grading, trimming, shipping	Trimming off mold and damaged cheese	Cheese solids

Flow Diagram 9. Cheddar Cheese Manufacture.

PLANT PROCESS	WASTE GENERATING PROCESS	NATURE OF WASTE
Milk receiving	Cleaning tank trucks & receiving equipment	Milk wastes & detergent
Milk storage & standardization	Separator sludge & cleaning sanitizing equipment	High solids waste milk wastes & detergent & sanitizer
Cream storage	Emptying & cleaning, sanitizer	Cream waste, detergent & sanitizer
Starter manufacture (skim milk)	Cleaning starter tank & lines	Starter (pH 4.6) solids, detergent & sanitizer
Curd making, cutting, cooking	Washing cheese vat, sanitizer	Curd particles, detergent & sanitizer
Whey draining, whey separation, & shipping	Whey - not excluded, separator sludge	Whey cheese "fines"
Forming and pressing	Curd transfer & pressing	Whey & pressings
Brine salting	Brine tank cleaning, trimming	Brine, cheese solids
Aging	Washing cheese	Cheese solids in wastewater
Grading, trimming, shipping	Cutting off mold & damaged areas	Cheese solids

Flow Diagram 10. Swiss Cheese Manufacture.

PLANT PROCESS	WASTE GENERATING PROCESS	NATURE OF WASTE
Milk receiving	Tank truck and/or can washing	Milk wastes & detergents & sanitizers
Storage & standardization	Cleaning storage tanks, sludge from separator	High protein milk wastes & detergents & sanitizers
Cream storage	Cleaning & sanitizing lines & tank	Cream waste & detergents & sanitizer
Starter manufacturing	Cleaning starter lines & tank sanitizing	Starter (pH 4.6) & detergent & sanitizer
Curd making, cutting, cooking, draining	Whey draining & cheese vat cleaning	Whey not excluded from drain & residual curd & whey & detergents & sanitizers
Curd stretching & texturizing (filata)	Mixing curd with hot water	High fat (2-6%) wash water
Mixing, molding	Forming curd under hot water, cleaning mixer	High fat wash water & fat from mixer & detergent & sanitizer
Brine salting	Cleaning brine tank (26% salt)	Salt & curd particles
Aging	Washing & trimming	Cheese solids
Trimming, distribution	Removal of molded & damaged portions of cheese	Cheese solids

Flow Diagram 11. Cheese-Pasta Filata (Provolone and Mozzarella) Cheese Manufacture

In Provolone and Mozzarella manufacture, the milling, mixing and molding of the curd produces a high-fat, low pH (5.1 - 5..3) washwater from which 3-5% fat can be recovered by centrifugation.

Ice Cream Operations. The unit operations and sources of wastes are indicated in Flow Diagrams 12-14 for ice cream, frozen dessert operations, and subprocesses. Alternative pathways are illustrated for novelty preparations. Because of high viscosity and high BOD values, incomplete draining of ice cream and ice cream mix lines and equipment can be a major source of BOD and suspended solids (SS) (nuts, fruits, etc.) in dairy food plant wastewater.

Manufactured Milk Operations. The unit operations and sources of wastes are indicated in Flow Diagram 15 for condensed milk processes and in Flow Diagram 16 for spray drying processes. The high viscosity and high BOD of condensed milk make any losses contribute greatly to the wastewater load. Spray drying plants have the potential for losses of dried product, which is often washed to the sewer and contributes greatly to increased BOD levels for these plants.

Wastewater Volume Coefficients for Various Plant Operations

Relatively little information is available concerning the amount of water per unit weight of milk processes as utilized in various types of dairy food plant operations (11, 22, 27 and 50). Information available in the literature and that obtained from industry has been summarized and presented in Table 13. Major processes utilizing water are wash water for cottage cheese, cooling water and condensing water. Cooling waters are generally free from waste and could be segregated from other operations to minimize hydraulic loading up to 70%.

Waste and Wastewater Loads

The volume and strength of dairy food plant wastewaters vary widely and information on water volume, and the strength of various wastewater parameters are reviewed elsewere (11, 22). For dairy food plants the average strength of various constituents in the wastewater are:

PLANT PROCESS	WASTE GENERATING PROCESS	NATURE OF WASTE
Receiving & Storage	Washing tank trucks & storage tanks	Milk wastes & sugar solids & detergent & sanitizer
Standardizing	Separator sludge & cleaning, sanitizing	High protein & cellular material
Dry ingredient blending	Ingredient spillage, sanitizing	High solids & milk waste
Mixing	Process vat, cleaning, sanitizing	Milk wastes & detergent & sanitizer
HTST pasteurization & homogenization	HTST start-up, change over & cleaning	Ice cream mix wastes & detergent & sanitizer
Cooling & storage	Cleaning lines & storage, sanitizing	Ice cream mix wastes & detergent & sanitizer
Flavoring fruits, nuts	Spillage & fruit feeder cleaning	Fruits, nuts & flavorings
Freezing	Product change over & cleaning, sanitizing	Ice cream mix & fruits, nuts & flavorings & detergents & sanitizers
Filling & conveying	Filling machine jams, broken packages, cleaning & sanitizing, conveying	Ice cream mix & fruits, nuts & flavorings & detergents, sanitizers & lubricants
Hardening & Distribution	Broken packages	Ice cream solids

Flow Diagram 12. Ice Cream.

UNIT PLANT PROCESS	WASTE GENERATING PROCESS	NATURE OF WASTE
Mix storage	Cleaning storage tanks	Ice cream mix & detergents & sanitizers
Ice cream freezer	Cleaning & sanitizing	Ice cream mix & detergents & sanitizers
To molds in refrigerated tanks	Machine jamming	Ice cream mix
Hardening	Brine replacement	Salt, ice cream mix solids
Dipping in coating	Dipping, product damage	Chocolate coating, ice cream & fruit juice solids
Bagging	Broken packages	Chocolate coating, ice cream & fruit juice solids
Storage	Broken packages	Chocolate coating, ice cream & fruit juice solids
Distribution	Returns	Ice cream solids & fruits & nuts

Flow Diagram 13. Ice Cream - Subprocess Stick Novelties.

PLANT PROCESS	WASTE GENERATING PROCESS	NATURE OF WASTE
From ice cream freezer	Cleaning lines & sanitizing -	Ice cream solids & detergents & sanitizers
Extruded onto conveyor	Equipment jamming & lost units of ice cream	Ice cream solids
Hardening tunnel dipping in coatings	Coating material spillage	Chocolate, nuts, cereals, etc.
Bagging, boxing overwrap	Broken packages	Ice cream solids
Extrusion, slice machine or ice cream sandwich machine	Packaging machine jams, cleaning & sanitizing	Ice cream solids, bakery solids
Wrapping, boxing overwrap	--	--
Hardening	Damaged products	Ice cream solids
Decorating	Damaged products	Ice cream solids
Storage	--	--
Distribution	--	--

Flow Diagram 14. Ice Cream - Subprocess - Stickless Novelties.

PLANT PROCESS	WASTE GENERATING PROCESS	NATURE OF WASTE
Milk receiving	Tank truck and/or can cleaning	Milk wastes & detergents
Storage standardization	Storage tank cleaning	Milk wastes & detergent & sanitizer
HTST or UHT pasteurization homogenization	HTST pasteurizer start-up & shut-down, cleaning, sanitizing	Milk wastes & detergent & sanitizer
Vacuum evaporation	Evaporator entrainment loss boil over cleaning	Cond. milk wastes & detergents & sanitizers
Storage	Storage, cleaning, sanitizing	Condensed milk & detergents & sanitizers
Can filling, conveying	Cleaning overfill machine jamming, conveyor lubrication	Condensed milk wastes & lubricants & detergents & sanitizers
Cooking & sterilizing	--	--
Casing	--	--
Tank truck transfer (fluid)	Clean-up of lines & equipment	Milk wastes & detergents & sanitizers
Distribution	--	--

Flow Diagram 15. Condensed Milk Process.

PLANT PROCESS	WASTE GENERATING PROCESS	NATURE OF WASTE
Condensed milk	Clean tanks & lines	Cond. milk wastes & detergents & sanitizers
Spray drying	Powder from collector	Dry milk waste washed to sewer
Screening & blending	Powder spillage	Milk wastes washed to sewer
Instantizing	Spillage	Milk wastes washed to sewer
Tablet making	Spillage	Milk wastes washed to sewer
Container filling & packaging	Spillage	Milk wastes washed to sewer
Storage	Spillage	Milk wastes washed to sewer
Distribution	Spillage	Milk wastes washed to sewer

Flow Diagram 16. Spray Drying Process.

TABLE 13. Coefficient Water Use For Various Plant Operations

OPERATION	GALLONS OF WATER/1000 LBS MILK
Can washing	0.12
Truck washing	8.4
Cooling milk in storage	23.9
Pasteurization	42.0
Bottle washer	60.0
Boilers and evaporators	30.0
Cleaning	30.0
Spray cleaning tanks	
Pre-rinses	0.6
Cleaning	1.2
Post rinse	0.6
Sanitizing	0.6
CIP of lines	
Pre-rinse	0.06
Cleaning	0.12
Post rinse	0.06
Sanitizing	0.3
Evaporating (3:1)(triple effect-calander conden.)	1079.
Condensing (triple effect-Plate condensor)	1439.
Cottage cheese wash water	144.
Cooling	
Receiving, bottling, ice cream & cream cheese.	144.
Receiving, past., separating, condensing and spray drying	132-180
Receiving, condensing, canning & sterilizing	2.4-48.

Component	Concentration (mg/l)
COD	4500
BOD	2300
SS	816
TS	2540
Fat	450
Nitrogen	56
Protein (N x 6.38)	358
Carbohydrate	1000
Chloride	200
Phosphorus	33

As mentioned earlier, presentation of water and waste data in coefficients (units/multiple unit of production of product) provide a useful means for data presentation and comparison.

Based on available information, Carawan (14) developed estimates of the coefficients for an average, typical multiproduct plant processing fluid milks, ice cream and cottage cheese by unit processes. These coefficients include both unavoidable and preventable losses and are based on average management control. Coefficients for unit process, water usage, wastewater discharge, BOD5, product loss and fat loss are presented in Tables 14-19 for processing fluid milk , buttermilk (cultured), sour cream, cottage cheese, frozen desserts, and for dairy food plant areas other than processing.

Coefficients Achievable Under Good Management

Coefficients for unavoidable wastes (design coefficient) provide a basis for determining the probable minimum water and waste loads for a given plant and a means for setting goals in a resource management control program. Water and BOD coefficients have been reviewed by Harper *et al.* (22) and Carawan (14). These values, while not absolute, do provide a reference base, which has been shown to be applicable in a number of dairy food plants. They were used to predict the probable BOD load for a new plant that has just gone into production. The estimated predicted value is within 10% of the actual BOD being discharged.

To determine the unavoidable (good management) waste load for a plant, the coefficients for applicable processes are added together and then multiplied by the unit of production. For example, the unavoidable BOD for a fluid milk plant processing only homogenized milk would be:

Table 14. Coefficients for Milk Processing in Case Study Plant(14)*

Process	Water Use	Wastewater	BOD Processed	Product Loss
Receiving	16	16	0.2	2.0
Separation	2	2	0.1	1.0
Clarification	2	2	0.1	1.0
Raw storage	20	20	0.2	2.0
HTST	110	100	1.3	13.0
Past. storage	20	20	0.2	2.0
Filling	10	10	0.3	3.0
Conveying	1	1	0.1	1.0
Returns	12	12	0.4	4.0
Distribution	5	5	–	–
Miscellaneous	10	10	–	–
Total	210	200	3.0	30.0

---

*Values based on gallons of water and pounds of BOD or product per 1000 pounds of 3.5% milk processed.

Table 15. Coefficients for Buttermilk Processing in Case Study Plant(14)*

Process	Water Use	Wastewater	BOD Processed	Product Loss
Vat past.	1200	1200	2.3	23.5
Vat cooling	120	120	-	-
Culturing	120	120	-	-
Past. storage	20	20	0.5	5.4
Filling	10	10	0.3	3.0
Conveying	1	1	0.1	1.0
Storage	2	2	0.1	1.0
Returns	12	12	0.4	4.0
Total	1485	1485	3.7	38.0

---

*Values based on gallons of water and pounds of BOD or product per 1000 pounds of 2.0% fat buttermilk processed.

Table 16. Coefficients for Sour Cream Processing in Case Study Plant(14)*

Process	Water Use	Wastewater	BOD Processed	Product Loss
Vat past.	1200	1200	10.8	46.2
Vat cooling	120	120	-	-
Homogen.	15	15	0.46	2.0
Culturing	120	120	-	-
Past. storage	20	20	5.4	23.0
Filling	10	10	0.7	3.0
Conveying	1	1	0.2	1.0
Storage	2	2	0.2	1.0
Returns	12	12	0.9	4.0
Total	1500	1500	18.7	80.6

*Values based on gallons of water and pounds of BOD or product per 1000 pounds of sour cream processed.

Table 17. Coefficients for Cottage Cheese Processing in Case Study Plant(14)*

Process	Water Use	Wastewater	BOD Processed	Product Loss
Skim transfer	1.2	1.2	0.08	1.0
Cream transfer	15	15	0.3	4.0
HTST	18	16	0.7	9.0
Starter prep.	12	12	0.3	4.0
Culture, cut, cook & drain	24	870	14.2	191.0
Washing	1500	1500	9.0	50.0
Cooling	370	370	0.6	3.0
Blending	75	75	2.4	12.0
Filling	40	40	0.4	1.0
Storage	2.5	2.5	0.4	2.0
Distribution	5	5	0.2	1.0
Dressing prep.	2	2	0.2	1.0
Total	2431	3081	112.0	82.1

*Values based on gallons of water and pounds of BOD or product per 1000 pounds of product processed. Whey is discharged to drain. Total BOD calculated on basis of per 1000 pounds of finished cottage cheese. Product loss is per thousand pounds of product, excluding whey.

Table 18. Coefficients for Frozen Product Processing in Case Study Plant(14)*

Process	Water Use	Wastewater	BOD Processed	Product Loss
Receiving	40	40	0.6	3.0
Storage	44	44	0.6	3.0
Standardizing	10	10	0.3	1.5
Blending	28	28	0.6	3.0
HTST	160	160	4.0	20.0
Past. storage	50	50	1.1	5.6
Flavoring, fruit and nuts	10	10	0.3	3.0
Freezing	110	110	2.4	12.0
Filling	70	70	1.0	5.0
Conveying	20	20	0.2	1.5
Hardening	-	-	0.3	1.5
Storage	3	3	0.3	1.5
Distribution	5	5	0.3	0.3
Total	550	550	12.0	60.1

*Values based on gallons of water and pounds of BOD or product per 1000 pounds of ice cream processed. Receiving based on receiving cream and condensed skim.

Table 19. Estimated Coefficients for Plant Areas Other than Processing (14)*

Process Area	Water Use	Wastewater	BOD Processed
Office	2.4	2.4	0.005
Garage	10.8	10.8	0.05
Boilers	22.8	22.8**	-
Cooling Tower	56.4	56.4	-
Shell-n-Tube	4320	4320**	-
Restrooms	6.5	6.5	0.01
Case Repair	1.2	1.2	0.01
Air Compressors	39	39**	-
Sweet Water	24	24	-
Refrigeration Compressors	144	144**	-

*Sanitary sewer unless noted otherwise.
**Storm sewer

Unit Process	BOD in lbs/1000 lbs milk processed
Tank truck receiving	0.2
Storage of milk	0.2
Pasteurization	0.8
Filling	0.1
Conveying, storage and shipping	0.05
	1.35

For a plant processing 500,000 pounds of milk per day, the unavoidable loss would be: 500,000/1000 x 1.35 = 675 lbs of BOD.

Design coefficients for water usage and BOD discharge are presented in Tables 20-24 for common unit operations in various fluid dairy food plants. Coefficients are presented in Flow Diagrams 17-24 for butter, cheese, frozen dessert, novelties, milk and dry milk operations. For convenience, the data are present in terms of units/1000 pounds of product processed. (One hundred pounds of BOD is the same as 1000 pounds of 3.5% milk.) Using calculations in Appendix 2, the data can be converted to units/100 lbs BOD or COD processed.

Design coefficients for milk, cottage cheese and ice cream processing are in Tables 25-27 for water usage, wastewater discharge, BOD5, product loss and fat loss by unit operations.

Table 20. Design Coefficients for Tank Truck Receiving*

Product Received	Gallons Wastewater/ 1000 lbs product processed	Pounds BOD5/1000 pounds product processed**,***
Skimmilk	15	.14
Whole milk	16	.2
Whey (sweet)	15	.8
Condensed skimmilk	18	.8
Cream (40% fat)	18	3.0
Liquid sugar	16	.9

*Based on unloading within one hour of arrival at plant.

**Based on no recovery of solids during rinsing.

***If unloading delayed for more than 3 hours after arrival at plant, BOD values for whole milk and cream should be multiplied by 2.0.

****If rinse recovery is utilized, reduce the wastewater coefficient by 1 gallon for skim, whole milk and whey, and 2 gallons for cream and condensed skim; reduce BOD coefficients by 75%.

Table 21. Design Coefficients for Storage of Fluid Products*

Product	Gallons Wastewater 100 lbs BOD processed	Pounds BOD/100 pounds BOD processed
Skimmilk	12	0.06
Low fat milk	12	0.12
2% Milk	13	0.18
Whole milk	13	0.20
Chocolate milk	13	0.5
Half & Half	13	0.48
Cream, 40%	14	3.0
Cultured buttermilk	15	1.12
Sour cream	15	7.0
Yoghurt	15	2.1
Ice cream mix	14	3.4
Condensed skim	14	0.8
Whey (no fines)	12	0.08

*Based on milk data corrected for difference in viscosity using H factors.

Table 22. Design Coefficients for HTST Pasteurization of Dairy Products*

Product	Gallons Wastewater/ 100 lbs BOD processed	Pounds BOD/100 pounds BOD processed
Skimmilk	60	0.7
Low fat milk	60	0.8
2% Milk	60	0.8
Whole milk	60	0.8
Half & Half	70	1.22
Cream (40%)	80	3.22
Ice cream mix	80	2.11
Condensed skim	80	1.7
Whey	60	0.3

---

*Based on milk data corrected for differences in viscosity using H factors

Table 23. Design Coefficient for Filling (Packaging) Various Products

Product	Gallons Wastewater/ 100 lbs BOD processed	Pounds BOD/100 pounds BOD processed
Skimmilk	6	.2
Low fat milk	6	.25
2% Milk	6	.25
Whole milk (3.25)	6	.3
Half & Half	6	.46
Cream (18%)	6	.65
Cream (40%)	6	1.2
Sour cream	3	
Ice cream	3	1.32

Table 24. Miscellaneous Design Coefficients

Operation	Wastewater/1000 lbs product processed	BOD5/1000 lbs product processed
Separation of Milk	1.8	0.08
Vat Pasteurization of Milk	36.0	0.5
Conveying & Cold Storage of Milk	3.0	0.2

PLANT PROCESS	GAL WASTEWATER/ 1000 LBS MILK*	POUNDS BOD/1000 LBS MILK PROCESSED*
Milk receiving	14.3	0.2
Separation	1.8	0.08
Skim storage, shipped out	6	0.15
Cream storage	12	0.3
Vat pasteurization	36	0.5
HTST past.	60	0.8
Churning	6	0.2
Washing butter	24	0.3
Printing and packaging	12	0.1
Storage and distribution	1.2	0.05
Total	174	2.6

*Values based on 3.5% milk equivalent processed or on 100 lbs of BOD processed.

Flow Diagram 17. Waste Coefficients - Butter, Churn Process.

PLANT PROCESS	GAL WASTEWATER/ 1000 LBS MILK*	POUNDS BOD/1000 LBS MILK PROCESSED*
Milk receiving	14.3	0.2
Separation	1.8	0.08
Skim storage, shipped out	12	0.15
Cream storage	12	0.3
HTST past.	60	0.8
Standardization	1.2	0.08
Continuous churning	12	0.2
Printing and packaging	12	0.1
Storage and distribution	1.2	0.05
Total	127	2.0

*Values based on 3.5% milk equivalent processed or on 100 lbs of BOD processed.

Flow Diagram 18. Waste Coefficients - Butter, Continuous Process.

PROCESS	GAL WASTEWATER/ 1000 LBS MILK*	POUNDS BOD/1000 LBS MILK PROCESSED*
Skim milk from separator	1.2	0.08
HTST pasteruization	60	0.7
Starter manufacture	12	0.3
Setting, cutting, cooking, draining	24	0.2 (whey excluded)
Washing three times	1200	8.0
Cooling	60	0.1
Cream from past. storage	15	0.3
Creaming	12	0.3
Packaging	6	0.1
Storage and distribution	1.2	0.1
Total	1390	10.0

*Values based on 3.5% milk equivalent processed or on 100 lbs of BOD processed.

Flow Diagram 19. Waste Coefficients - Cottage Cheese.

PLANT PROCESS	GAL WASTEWATER/ 1000 LBS MILK*	POUNDS BOD/1000 LBS MILK PROCESSED*
Milk receving	12	0.2
Milk storage and standardization	12	0.28
Cream storage	12	0.3
Starter manufacture, (skim)	12	0.25
Curd making, cutting, cooking and draining	12	0.2 (whey excluded)
Cheddaring, milling, salting	-	0.1
Washed curd, processing, salting	24	0.5
Hooping, forming, pressing	-	0.3
Aging	0.5	0.05
Grading, trimming shipping	-	0.05
Total	92	Cheddar 1.25 Washed curd 1.7

*Values based on 3.5% milk equivalent processed or on 100 lbs of BOD processed.

Flow Diagram 20. Waste Coefficients - Cheddar and Washed Curd Cheese Manufacture.

PLANT PROCESS	GAL WASTEWATER/ 1000 LBS MILK*	POUNDS BOD/1000 LBS MILK PROCESSED*
Mix storage	1.8	0.3
Ice cream freezing	18	0.5
To molds in refrigerated tank	30	0.3
Hardening	12	0.4
Dipping in coating	-	0.25
Bagging	-	0.3
Storage	1.2	0.1
Distribution	-	0.1
Total	63	2.0

*Values based on 3.5% milk equivalent processed or on 100 lbs of BOD processed.

Flow Diagram 21. Waste Coefficients - Ice Cream Sub-process -Stick Novelties.

PLANT PROCESS	GAL WASTEWATER/ 1000 LBS MILK*	POUNDS BOD/1000 LBS MILK PROCESSED*
From ice cream freezer	18	0.3
Extruded onto conveyor	6	0.1
Hardening tunnel-dipping in coating	-	0.1
Bagging, boxing, overwrap	-	0.05
Extrusion, slice machine or ice cream sandwich machine	6	0.1
Distribution	12	0.1
Decorating	6	0.15
Storage	1.2	-
Distribution	-	-
Total	98	0.95

Values based on per 1000 pounds of milk equivalent processed or per 100 pounds of BOD processed.

Flow Diagram 22. Waste Coefficients - Ice Cream Sub-process -Stickless Novelties

PLANT PROCESS	GAL WASTEWATER/ 1000 LBS MILK*	POUNDS BOD/1000 LBS MILK PROCESSED*
Milk receiving	15	0.2
Storage, standardization	1.8	0.18
HTST or UHT, pasteurization, homogenizaton	60	0.8
Vacuum evaporation	1080	0.25
Storage	15	0.3
Can filling, conveying	12	0.1
Cooking and sterilizing	36	0.05
Casing	6	-
Tank truck transfer	15	0.3
Total	1380	1.88

*Values based on 3.5% milk equivalent processed or on 100 lbs of BOD processed.

Flow Diagram 23. Waste Coefficients -Condensed and Evaporated Milk Process

PLANT PROCESS	GAL WASTEWATER/ 1000 LBS MILK*	POUNDS BOD/1000 LBS MILK PROCESSED*
Condensed milk from storage	15	0.3
Spray drying	6	0.2
Screening and blending	1.2	0.1
Instantizing	24	0.1
Tablet making	-	0.1
Container filling and packaging	6	0.1
Storage	1.2	0.05
Distribution	-	-
Total	53	0.85

*Values based on 3.5% milk equivalent processed or on 100 lbs of BOD processed.

Flow Diagram 24. Waste Coefficients - Spray Drying Process.

Table 25. Design Coefficients for Fluid Milk Processing

Process	Code	Water Use (BUYWA)	Effluent (SANSEW)	BOD_5 Processed	Product Loss (milk loss)	Fat Loss
		(gal/1000 lb)	(gal/1000 lb)	(lb/1000 lb)	(lb/1000 lb)	(lb/1000 lb)
Receiving	RC	16	16	0.15	1.5	0.05
Separation	PR	2	2	0.025	0.25	0.008
Clarification	CL	2	2	0.025	0.25	0.01
Raw Storage	RS	20	20	0.15	1.5	0.05
HTST	HT	80	40	0.3	3.0	0.11
Pasteurized Storage	SP	20	20	0.15	1.5	0.005
Filling	FF	15	15	0.1	1.0	0.035
Conveying	CV	1	1	0.05	0.5	0.012
Storage	SF	10	2	0.05	0.5	0.012
Miscellaneous	--	10	10	--	--	--
TOTAL		176	128	1.0	10	0.34

Table 26. Design Coefficients for Cottage Cheese Processing
(whey not recovered; assume 0.1% fines loss)

Process	Code	Product	Water Use (BUYWA)	Effluent (SANSEW)	BOD_5	Product Loss* (CC Loss)	Fat Loss
			(gal/1000 lb)	(gal/1000 lb)	(lb/1000 lb)	(lb/1000 lb)	(lb/1000 lb)
Skim Transfer	TCCSMUS	Skim	1.2	1.2	0.08	1.0	0.0001
Cream Transfer	CCCMUS	Cream	15.0	15.0	0.30	4.0	0.0004
HTST	CCHT	Skimmilk	16.0	16.0	0.22	3.0	0.0003
Starter Preparation	CCST	Starter	10.0	10.0	0.30	4.0	0.0004
Set, Cut & Cook**	CCMF	Skimmilk	24.0	24.0	0.1	1.39	0.0019
Drain***	CCDR	Curd	10.0	450.0	10.3	10.0	
First Wash	CCW1	Curd	658.0	658.0	7.0	35.0	0.008
Second Wash***	CCW2	Curd	658.0	658.0	3.0	15.0	0.004
Third Wash**	CCW3	Curd	329.0	329.0	1.0	5.0	0.009
Blending	CCBL	Curd	75.0	75.0	1.0	5.0	0.03
Filling	CCFF	Cottage Cheese	40.0	40.0	0.2	1.2	0.0036
Storage	CCSF	Cottage Cheese	2.5	2.5	0.1	0.5	0.003
Distribution	CCSH	Cottage Cheese	5.0	5.0	0.1	0.5	0.0015
Dressing Preparation	CCDS	Dressing	2.0	2.0	0.2	1.0	0.003

*Whey excluded

**Changed Code designation

***New Process

Table 27. Design Coefficient for Ice Cream Processing
(data in gallons or pounds/1000# of product produced)

Process	Code	Water Use	Wastewater	BOD_5	Product Loss	Fat Loss
		Ice Cream Processed				
		(gal/1000 lb)	(gal/1000 lb)	(lb/1000 lb)	(lb/1000 lb)	(lb/1000 lb)
Receiving	(RMRC)	35	35	0.33	1.0	0.3
Storage	(RMST)	30	30	0.33	1.0	0.3
Standardizing	(RMSP)	10	10	0.15	0.5	0.2
Blending	(ICBL)	28	28	0.33	1.0	0.3
HTST	(ICHT)	80	80	2.0	10.0	2.0
Pasteurized Storage	(ICSP)	50	50	0.6	2.5	0.56
Flavoring, Fruit and Nuts	(ICIN)	10	10	0.3	1.5	0.15
Freezing	(ICAF)	50	50	1.0	0.3	1.2
Filling	(ICFF)	20	20	1.0	0.3	0.5
Conveying	(ICCV)	10	10	0.1	0.03	0.1
Hardening	(ICZZ)	--	--	0.1	0.03	0.2
Storage	(ICSF)	3	3	0.1	0.03	0.2
Distribution	(ICSH)	5	5	0.1	0.03	0.2
TOTALS		331	331	6.44	16.72	6.2

Determination of Preventable Wastes

Since most data for organic waste load coefficients are reported in terms of BOD, the use of BOD coefficients to estimate preventable wastes is somewhat easier in many cases, even though COD is a more rapid method for assessing losses. To determine preventable wastewater levels and BOD loads (or COD where coefficients are available), first determine the design coefficients for the plant using appropriate unit processes. Then take the coefficients determined from the preliminary survey and subtract them from the design coefficients. The difference times the amount of product processed gives an estimate of the total daily reduction in wastewater and BOD (COD) that is potentially achievable.

2. Detailed Plant Survey and Special Studies

After the initial survey, and the determination of preventable vs. unpreventable wastes, a series of detailed studies need to be undertaken as outlined in Table 28.

Table 28. Detailed Surveys

A) Continuous Wastewater Survey

A continuous survey of wastewater and waste strength being discharged from plant. This will involve measurement of flow and sampling -- preferably on a flow composite basis. Analysis will be made to provide continuous data on waste loads.

B) Water Use Survey and Balance

Determination of water coming into the plant and specific determination of water utilization within the plant.

C) Materials Balance

Determination of products in and products out to determine product losses. This will include determination of the COD (BOD) lost related to product lost.

D) Departmental and Unit Process Survey

Study of the contribution of individual unit operations (and different departments in a multiproduct plant) to the water and waste loads.

E) Energy Survey

Determination of energy losses by unit processes and by department.

The analyses to be made will depend to a large part on permit and/or municipal ordinance requirements. In most cases, these will include volume, BOD and suspended solids. In many cases, analyses will also be required for nitrogen, phosphorus, chloride, and FOG.

For rapid results, that can be useful in assessing losses, and also to approximate BOD, the COD test provides some very real advantages. The test can be accomplished in 2-3 hours as compared to 5 days and does provide a means for assessment of product loss. To estimate BOD it is necessary, over a period of time, to establish a BOD/COD ratio and this ratio can be utilized to predict an approximate or estimated BOD. In most plants, over a continued period of time, the ratio will be relatively constant, although the ratio from individual unit operations may vary widely. An industry average of 0.45 ± 0.03 is common for most dairy plant operations.

Recommendation is made that COD and flow measurements be made on a regular basis on a 24-hour composite. The time of initiating and stopping samples should be related to the beginning of the work day and will vary widely from plant to plant. It is extremely useful to take a series of samples and to correlate these samples with operations within the plant. This study may be of a relatively short-term basis on detailed analysis, such as over a 2- or 3-week period. However,continuing to take multiple samples and compositing them on a daily basis has the value of being able to very rapidly assess what has happened in the previous 24 hours. Visual inspection of the samples provides an insight as to periods of major losses.

Water meters should be installed at all high use areas, as well as meters for determination of water used in product make-up, cooling towers, compressors, etc. An accurate measurement of water in vs. water out provides a basis for establishing a more realistic charge basis for municipalities. Most municipalities, in the absence of records, will charge for waste treatment at a volume equal to that of the water coming into the plant. Records provide a basis for obtaining charges on waste volume discharge only.

3. In-Plant Control

Production Scheduling

Zall and Jordan (57) pointed out that scheduling is one of the best waste controls in the dairy processing plant. An example is given of running chocolate milk between two white products, thereby requiring two water rinses between the products with the flushing of product to the sewer.

Unnecessary shutdowns or other interruptions were said to almost always produce product losses to the sewer. These unnecessary shutdowns might be prevented if written records as to the cause of stoppages were made, enabling corrective action (Zall and Jordan, 57).

The scheduling of production should be on a specified schedule, with care being taken to prevent "crisis" marketing orders from altering the schedule with the possibility of markedly increasing losses. Unscheduled shutdowns and start-ups of HTST units waste water and product. Care should be taken to ensure that no excess product is kept in storage tanks over a weekend with subsequent spoilage and dumping of product. These are but two examples of how product scheduling interfaces with waste control. Careful planning and coordination with marketing to avoid change in planned schedules is important.

The preparation of a Gant chart (chart showing the timed use of each piece of equipment in the plant) is useful to determine optimum scheduling and minimizing losses.

Maintenance Program

The level of control of water and wastes in a dairy food plant can be correlated directly to the maintenance program in operation in the plant. A good waste management control program cannot be achieved without a good maintenance program. It should be stressed that a maintenance program involves more than the engineering department. Effort by operators of equipment is also essential to the maintenance program. Communication bewteen operators and plant engineers is essential. Too often a situation develops where the operator states that the problem is because the engineer hasn't fixed the equipment, and the engineer says that the operators are using the equipment incorrectly. In such instances, nothing gets done and waste can increase markedly. Also in such cases, there is often a bit of truth in the viewpoints of both parties. This interface between engineer and operator is a critical one and must be recognized by management and the Waste Control Manager as a key in the success of the waste control program.

The larger the plant, or the more shifts in operation, the more difficult is the achievement of good waste control and a continuing good preventive maintenance program. Recognition must be given to the need for adequate supervision of second and third shifts, in order to obtain the greatest efficiency from the engineering crew.

A maintenance program should be separated into four parts: (1) emergency repair, (2) "chronic" repair or minor repair, (3) operator-associated maintenance, and (4) preventive maintenance. Of these, the operator-associated maintenance and the preventive maintenance programs are most important to waste control and generally the ones given the least attention.

a. Operator Responsibilities

Management is responsible to see that operators are fully trained in the use and operation of assigned equipment. The Chief Engineer, or the Waste Control Manager, as training officer, should instruct each new operator on the engineering aspects of the particular equipment. In the latter instance, the Chief Engineer should provide information and follow-up to insure that the operator is familiar with all essential engineering-related information. This should include:

1. Information on how to disassemble equipment, including tools to use and precautions in handling each subpart to prevent any damage -- especially to metal-to-metal contact surfaces that could cause leakage.

2. Detailed instructions on machine settings. This is particularly important in respect to packaging equipment, where there may be a number of settings that must be made on a regular basis. The operator should understand the interdependence of the settings on complex equipment.

3. Instruction on how to assemble lines and equipment and how to check on proper alignment and set-up.

4. Instruction on the interrelationship between the operator's job and other operations in the plant that may result in wastes. Compliance to pre-planned production scheduling can be a factor in a maintenance program and also to plant losses.

5. Instruction on proper shut-down procedures for the equipment in an emergency situation.

6. Information on how to initiate maintenance requests.

Above all, the operator must exercise care in the handling and operation of the equipment and to minimize engineering repair requirements and also to minimize direct loss through leaks, spills, etc.

Changes in equipment settings such as level control in storage tanks should not be made by operators as a substitute for proper production scheduling.

b. Preventive Maintenance

A regular program of preventive maintenance should be in continual operation. In many multi-shift plants, this preventive maintenance may be best fitted into the third shift -- since this is generally the period of lowest processing operation in most plants. A sufficient engineering staff should be available to take care of emergency repair and also provide for a continuing preventive maintenance program. A preventive maintenance program includes:

1. A regular planned replacement of worn parts, gaskets, and fittings.

2. A regular routine inspection of the plant on a planned basis, giving attention to leaking connections, valves and pump seals. In complex, multi-product plants, a rotational basis for regular inspection of components may be desirable. A few units per day or per week to provide complete review every three months may be adequate. Where leaks are noted, a work order should be placed for routine repair on a priority basis--with the most serious situations being given the highest priority (once a week).

3. Routine and regular checks of pipelines, to make sure that lines have retained their pitch and that they are free from vibrations (every 4 months).

4. Routine inspection and planned replacement of rubber gaskets and "O" rings on automated valves, filler parts, etc. (every 3 months).

5. Check of air-blow systems on a planned basis (every 2 months).

6. Check on operation of high level and low level controls (once a month).

7. Check on accuracy of indicating thermometers (once a month).

8. Inspection of settings on packaging machines (once a month, or more often as required).

9. Check filler valves and regrind as required.

10. Check homogenizer packagings (once every 2 weeks).

11. Check on seals and automatic desludging systems on separators. Proper setting of pressures is essential to eliminate leakage. Automatic desludging separators should be checked during desludging to make sure the system is operating properly and not sticking open.

12. Check on equipment leaks (homo, pumps, etc.) that may cause overflows.

13. Regularly check on flow and pressure drops in CIP systems to insure proper operation (every month).

14. Check proper operation of manual and automatic air-blow systems (once a month).

15. Regularly inspect water hose stations to insure no leakage of shut-off valves or supply lines, valves and fittings; have defective automatic shut-off valves replaced (every 2 weeks).

16. All manual and CIP fittings should be inspected and replaced on a regular basis as needed (every 2 months).

17. Pump seals should be checked regularly to insure that they are not leaking and request repair and/or replacement whenever leaks are noticed (weekly).

18. All pipe connections should be checked regularly to insure that they are not leaking product or permitting the incorporation of air into the product which would cause foam (monthly).

19. All cases, conveyors, and stackers should be maintained in proper adjustment to avoid jamming and subsequent loss of product from spillage or broken packages (every 2 weeks). Check machine adjustments to insure proper filling, capping and sealing.

20. Plastic and glass bottle fillers and cappers should be maintained in excellent condition to avoid breakage and product losses. A regular maintenance program should be adopted to maintain these machines in top operating condition to avoid jams and product spillage (weekly).

21. High and low level controls should be checked to

make sure that they are in continuous operating condition and that settings have not been altered (weekly).

A detailed preventive maintenance schedule for a milk, cottage cheese and ice cream plant is in Appendix 8.

c. Operational Maintenance

The successful waste management control program requires continuous daily attention to detail. This involves the operators checking the equipment during start-up, ensuring that all fittings are tight and that no seals are leaking on the pumps. It also requires continued attention to the operational performance of the equipment, proper setting of machines and when small parts are being cleaned up, attention must be given to care of the equipment to avoid damage. At the same time, there is a necessity to have open communication channels between the production and maintenance operations. Problems that require maintenance attention should be communicated promptly and follow-up, if possible, should be through the continuing preventive maintenance program.

d. Maintenance Follow-Up

The Waste Control Manager should be making daily inspection tours through the plant, communicating with plant operators to determine any new equipment problems and to check on follow-up on uncompleted repairs and find out why corrections have not been made and then take steps to facilitate the corrections. Unless maintenance problems are promptly attended to, the attitude of the operators will become negative, they will fail to report problems, and will lose interest and motivation.

Regular Dairy Plant Control Procedures

a. Receiving Operations

The primary operation in receiving is tank truck receiving. Important aspects for waste control in tank truck receiving are the following:

1. Make sure that each tank is properly connected to the transfer pump on initial unloading of the first tank for the day; check should be made to ensure that all couplings and pump seals are not leaking. Immediate attention should be given to attempting to correct any leaks that are observed. If leaks cannot be corrected, then a request should be made to maintenance to make repairs.

2. Tank trucks should not be permitted to stand more than one hour prior to unloading. Long standing of tank

trucks in the quiescent state permits creaming, and once creaming occurs, even extensive agitation will not prevent adherence of the cream material to the sides of the tank.

3. Allow adequate time for the tank truck to drain prior to disconnecting the transfer hose. Care should be taken to show that all product in the transfer hose has been properly emptied prior to disconnecting the tank.

4. Where legally acceptable, a 20-40 gallon burst rinse flush of the tanker with portable water should be made and this transferred to the raw silo. This is only feasible in large plant operations, where we're dealing with receipts into 20,000 gallon or larger silo tanks. The dilution factor for a standard tanker will be less than 0.01%. An alternative is to transfer the initial rinses to a refrigerated recovery tank and then put this rinse through to HTST at the end of the day to rinse lines. The product may be used for feed or for product, depending on health department regulations.

b. Can Receiving

1. Utilize a product-saving pre-rinse at the end of the can washer over the drip pan saver with adequate time for complete drainage.

2. The weigh tank must be properly assembled and free from all leaks from fittings and pumps.

3. Raw milk lines are generally filled with milk between receiving different lots of the product; at the end of the total receiving operation all milk should be removed from the lines between the receiving room and the storage tanks. In most modern operations this is accomplished by air blow down. In all cases the lines must be emptied prior to cleaning to avoid extensive product losses.

c. Processing

1. All sanitary fittings, valves, rotary seals, pump parts and filler parts must be handled with extreme care during every phase of operation to prevent damage to the surface which may cause leaks. Small parts should be properly washed in small parts washers and placed on rubber mats for draining to minimize any damage.

2. Do not use a constant running water hose in any area.

3. Employees should either eliminate the cause of spillage or report it to the Waste Control Manager rather than washing away spilled product. Valves, pipelines, pumps should

be properly installed, and gaskets installed and carefully seated to prevent leakage.

4. Thoroughly drain all lines, tanks, and processing vats before rinsing. The process equipment surfaces should be rinsed as soon as possible after use so that the product does not dry on and increase cleaning requirements.

5. Make sure that all lines on the suction side of pumps are properly sealed to avoid air leaks and resultant foaming which can cause excessive waste.

6. Make sure that correct connections are made on plate type heat exchangers so that there is no possibility of milk being pumped to the water side of the exchanger or water being pumped to the milk side.

7. Make sure that all worn and obsolete equipment is observed during plant operations and reported to maintenance for repair.

8. Drips and leaks occurring during processing runs should be corrected if possible and if it is not possible, then the drips should be collected in containers and not allowed to go down the drains.

9. Where drip shields are supplied, they should be in place and provided with adequate containers for each day's operation.

10. For processing vats that are not supplied with high level shut-off controls, the employee is responsible for filling the processing vat and should pay careful attention to the filling operations so that overflows do not occur.

11. Make sure automated air-blow systems are in operation. For manual air-blow systems, do not actuate for more than 3 seconds, since this will empty the line into the tank and allow for product to reenter the pipe.

d. Packaging and Handling of Products

1. Bottles should be inspected carefully at the beginning of the bottle washing operation so that defective bottles do not get to the filler and thus avoid product losses.

2. For plastic and glass bottle fillers, cappers should be maintained in first-class condition to avoid breakage and/or product loss. Where blow molding is in use, quality control of the package weight is a continuing requirement.

3. Paper filling machines must be maintained in proper operating condition during operation. Settings on paper forming equipment should be checked frequently to insure proper package formation and sealing to minimize leaking.

4. Filler valves should be checked to see that all containers are filled to correct capacity. In glass bottles, filling up to the cap seat may create spillage when milk is forced up past the cap seat with temperature changes.

5. Operators should check the filler supply bowl for foam and eliminate any foam to minimize spillage and help insure proper operating of packaging machine.

6. Bottles and plastic and paper containers should be handled carefully during casing, stacking, loading and delivering to avoid product losses.

7. Spilled dry ingredients should be handled as solid waste and not washed down the drain.

8. Return products or products that have to be repacked should be handled in a sanitary manner and collected to use as animal feed and not discarded to the drain.

9. Products that are damaged and dumped at the fillers should be recovered in a sanitary recovery system. The transfer should be made promptly without allowing the product to warm to any degree to minimize microbial growth. This product can be reused in ice cream or some special products, providing that it meets microbiological standards.

10. Product remaining in the filler bowls of the milk operation should be drained and collected at the end of the processing day and not be merely rinsed to drain.

e. Cleaning and Sanitizing Wastewater Handling

1. Care should be taken to avoid incorporation of cleaning compounds and/or sanitizing solutions into milk products, thus eliminating the need for disposal of large quantities of milk solids.

2. Concentration of cleaning and sanitizing compounds needs to be carefully controlled. Where cleaning compounds are added by hand, only sufficient cleaning compounds necessary to insure adequate cleaning and sanitizing should be used to minimize discharge of potentially toxic materials or wastes at excessively high or low pH levels.

f. Distribution

Care should be exercised in the handling of packaged products to minimize the leakage of damaged packages in the delivery truck.

g. Special Recommendations

Cheese Plants. A number of practices for waste control are recommended for cheese plants. They include the following:

1. Employees should be paying particular attention to cheese vats during filling so that they will not be overflowed, with subsequent loss of product to the drain. Liquid level in the cheese vats should be at least 3 inches below the top edge of the vat to prevent spillage during agitation. All valves, pumps, and line fittings should be checked on a daily basis to make sure that they are leak free.

2. In cheese operations, especially in acid set cheese, particular care needs to be taken in determining the time of cut, and in handling the curd during initial cooking and subsequent mechanical handling and any other operation. This is essential to minimize curd fines, which can contribute up to 30% of the organic waste load going out with the whey or with wash water in the case of cottage cheese.

3. All spills of curd particles from cheese operation should be swept up and handled as solid waste and not washed down the sewer drains. After the curd has been removed from the vat, the remaining curd in the vat and outlet valve, which can be up to 1-20 pounds per vat, should be washed out of the vat, collected in a strainer and handled as solid waste. If this material is handled properly it can be utilized for pet food or animal feed.

4. Any mechanical handling equipment for curd should be inspected daily to insure that the equipment is operating properly and that the settings on the machinery are proper to minimize loss.

Ice Cream Plants. Recommendations for waste prevention and control in ice cream processing include:

1. Avoid overfilling ice cream mix vats to eliminate the spillage of high BOD-containing materials during agitation. During filling, attention should be maintained on the filling operation to avoid overflow.

2. Food stuffs and other dry ingredients from ice

cream operations should be swept up and treated as solid waste.

3. Ice cream mix has a very high BOD level and frozen products that are dumped on the floor during filler breakdowns should not be washed down the drain but placed in a container for handling either as a high solids waste or for animal feed. The collecting container for ice cream that cannot be used as rerun (has come into contact with contamination in jammming of a packaging machine) has to be made convenient enough for operators to utilize it. Collection of this material on a mobile 55 gallon drum wheeled cart, followed by freezing and utilization as animal feed is to be preferred to dumping it down the drain.

4. Products that are not normally used for rerun, such as sherbet, require special handling as solid waste. Care should be taken in scheduling to avoid having excess mix at the end of the day that must be discarded.

5. Because of propensity for jamming, the operator must give continual attention to the settings on the packaging equipment to avoid jams. Wherever feasible, automatic recycle needs to be put into operation to divert ice cream if the system jams.

6. During wash-up, the lines and freezers should be rinsed with a minimal volume of water on a time-controlled basis. This material should be used for rerun since it could be handled in a completely sanitary manner. Rinsing should be done with fully potable and microbiologically satisfactory water. In plants where water is contaminated with psychotrophic organisms, this could require a pre-chlorination.

7. Novelty operations are especially prone to high losses. **The minimization of losses from novelty operations** requires careful and continual attention by both operators and maintenance people to avoid problems. The following are common things that need to be given attention:

a) Proper setting of water flow controls to ensure proper extraction and complete cleaning of molds.

b) Proper setting of freezing temperature so that the stick is properly placed in the novelty.

c) Checking to be sure that the springs are present on the extractor bars for the novelty operation and that the spring tension is correct.

d) Proper setting of defrost temperature to ensure extraction without excessive melting.

e) Continued attention to the stick feed to be sure that the sticks are available and feeding properly without jams.

f) Continued attention to the settings on the bagging and boxing machines to avoid jams. Good operation of the freezing operation minimizes problems with bagging and packaging.

Condensed and Dry Milk Products. Plants manufacturing condensed and dry milk products should especially follow these recommendations:

1. Where hot wells are utilized, care must be taken to avoid overfilling and to prevent boiling over.

2. Evaporators should be operated at sufficiently low liquid level as to prevent product boiling over.

3. Where dry ingredients are utilized, or where milk powder is spilled on the floor, contents should be swept up and not washed into the sewer.

4. Care must be taken in materials handling to avoid breakage of containers and product spillage.

5. During start-up and shut-down of condensors (evaporators) the product water mixture should be saved for rerun. Most operations can be started up and stopped by careful operator attention to minimize losses at this point.

6. Careful attention needs to be given to lactose crystallization and storage of condensed product to minimize precipitation of lactose crystals and loss of product that cannot be pumped.

4. Resource Information for Management Control

In addition to the factors already considered, a managment control program must also consider the following:

- by product utilization, including recovered wastes such as product line rinse.
- waste segregation
- process and equipment alternatives that can reduce the level of unavoidable (or design waste) loads.

These factors will be considered differently in different dairy plant operations, so that no single approach can be suggested. The following information provides a brief review of recent literature pertaining to these topics.

a. Segregation of Dairy Wastes. Zall (56) pointed out that stringent regulatory control forced operators to prevent water from being mixed with dairy products. He noted that piping and equipment in a dairy plant will sometimes dictate inherent product losses. He noted that dairy plant management can successfully recover product losses and salvage these materials for useful purposes.

Harper *et al*. (22) cautioned that when planning new dairy plants or remodeling existing facilities consideration should be given to the segregation of those sewers expected to receive high BOD5 wastewaters. Wastewaters from high BOD5 drains could be returned to a tank to be metered out for waste load equalization or subjected to pretreatment. They indicated that lubricants, milk from filling areas, solid particles from cottage cheese operations, HTST discharge and CIP discharges would all be areas to consider segregating and combining into a high strength waste.

Besides strong process wastes, wash waters, cooling waters and sanitary wastes, there are other waters that may be segregated (Milk Industry Foundation, 34). Wastes should be segregated to reduce the volume and to reduce the strength of wastewaters. Either of these can reduce the installation and operating costs of waste treatment facilities. Surcharges can also be reduced (Carawan *et al*., 11).

b. By-Product and Waste Product Utilization. Harper *et al*. (22) pointed out that because of the national attention and visibility of whey as a waste product, the dairy industry was aware of the significance of using whey as a food or feed product to minimize pollution and to gain a profit from such operations. However, they indicated that the dairy industry was less aware of the potential in respect to the utilization of product rinses, dilute milk solutions resulting from start-up, change over and shut-down of pasteurizers on water, which is a major source of BOD5 in most milk plants; and the recycling or utilization of returned product.

The complete removal of whey from wastewaters is a continuing problem in the United States (22). It was estimated that about 20% of all the milk processed ends up as whey of one type or another. There is a limited market for whey solids. Technological problems exist in developing products from whey. The presence of from 0.5 to 0.7% lactic acid in acid whey provides problems in respect to drying the material and also in respect to its utilization in food (22).

Jonas et al. (25) estimated that for the entire United States from 70 to 74% of the sweet whey is utilized while only 20% of the acid whey is utilized. Development Sciences, Inc. (1975) concluded that small to medium size cheese plants need assistance to efficiently utilize energy to recover whey components for food instead of treating the whey as a wastewater.

Foam spray-drying, foam mat-drying, reverse osmosis, gel filtration, electrodialysis, hydrocolloid protein precipitation, ultrafiltration for protein recovery, utilization for the growth of yeast protein, fermentation and animal feed use are all methods which have potential for the conversion of whey into more usable forms (22). Schingoethen (39) has reviewed feeding whey to animals and reports that ruminants can consume up to 30% of their dry-matter intake as liquid whey while swine often experience diarrhea if more than 20% of their dry matter is liquid whey. Further, calves have been fed up to 89% dried whey with favorable growth rates.

Dairy companies have often had trouble marketing whey products for a profitable return. A number of uses for cottage cheese whey are tabulated in Table 29. However, converting whey into usable products for feed or food results in a reduction of cost to a dairy operation where they are faced with an absolute limit on BOD5 in the wastewater, when they are paying a surcharge on BOD5 or when they are treating their wastewaters for discharge to surface waters.

Watson et al. (51) reported on recent investigations with spreading whey on agricultural lands. Proper practices for land spreading were detailed and explained. They reported that up to 102 mm of whey applied yearly produced improved corn yields and that the beneficial effect could be observed a year after application.

Jelen and Buchheim (24) examined the disposal of cottage cheese whey from small dairy plants by sewer dump with a surcharge, drum drying, evaporation and the making of mysost cheese. The manufacture of the mysost cheese was the best economic alternative.

Lowenstein et al. (29) used fractions or derivatives made from cottage cheese whey to replace part or all of the nonfat dry milk solids in ice cream formulations. Neutralization by potassium hydroxide (KOH) and protein precipitant removal was the first step followed by concentration either in vacuum pan or by ultrafiltration. Lactose hydrolysis was also utilized on all or part of the lactose to get a more desirable final product.

Harper et al. (22) expressed the opinion that one of

Table 29. Selected Cottage Cheese Whey Use or Conversion Citations

Use or Component Recovery		References
Macaroni additive		Anon., 1976
Ice cream formulations		Lowenstein, 1975
Protein recovery by chitosan		Bough and Landis, 1976
Production of mysost cheese		Jelen and LeMaguer, 1976 Jelen and Buchheim, 1976
Nutritional composition		Glass and Hedrick, 1976a 1976b
Drying		Pallanch, 1973
Electrodialysis of raw whey or RO/UF fraction		Johnson et al., 1976
Protein production of fermentation		Tzeng et al., 1975 Bernstein and Everson, 1974
Wine production		Yang et al., 1975
Fibrous protein		Jaynes and Ascan, 1976
Membrane processing	UF/RO	Crowleys Milk Co., 1971
	UF/RO	Zall and Goldstein, 1973
	UF	Robe, 1976
Baking or confections		Guy, 1973 Alikonis, 1973
Beverages		Holsinger, 1973 Demott, 1975
Animal feeding		Gordon et al., 1973 Nielson, 1973 Morrill, 1973 Schingoethe, 1976
Land disposal		Watson et al., 1977

the most promising developments in respect to whey utilization lies in recovering the protein fraction. The nutritional value of the whey protein exceeds that of casein and the protein has unique whipping and emulsifying properties. Removal of the protein from the whey reduces the whey solids approximately 13% and the BOD approximately 20%.

Nickerson (37a) reviewed the use of the milk derivative, lactose, in other foods. Lactose use in foods was based on its specific properties which were given as relative sweetness, browning reaction, protein stabilizing properties, alteration of crystallization patterns, flavor accentuation, selective fermentation and nutritional attributes. Specific food uses listed included toppings and icings, fresh-pack pickles, baked goods, candy, milk based beverages, beer, wine and infant foods.

Harper et al. (22) indicated the potential exists for elimination of all the milk solids present in rinse waters from tank truck, storage tanks, lines and equipment, for saving the milk solids diverted to drain in the start-up, change over, and shut-down of HTST pasteurizers and for removal of milk solids put into the wastewater by virtue of returned products. They estimated that up to one pound of BOD5 per 1000 pounds of milk processed could be eliminated through the collection and utilization of these solids. Also, in the case of highly viscous products, such as cream, churned buttermilk, sour cream, yogurt, ice cream mix and similar products, they estimated the amount of BOD5 that could be recovered from wastewaters might be as high as 3 pounds per 1000 pounds of product in some plant operations. These diluted milk solids are considered to be adulterated products by many health officials and changes in laws and regulations will have to be made to permit their utilization in foods (Appendix C). They observed that methods for segregation and utilization of these dilute materials are needed. Two possibilities were mentioned with present laws and technology. First, a possibility exists at the present time of using them in ice cream mix or any other products where solids must be added to the material. Second, the possibility also exists of utilizing reverse osmosis to concentrate the materials.

Zall (56,57) mentioned the following for salvage of dairy products:

1. Use collected rinsings in existing products.
2. Create new products to utilize the rinsings.
3. Use rinsings for animal feed, or
4. Find a buyer for the diluted product.

Harper et al. (22) related that dairy automation systems could be used to help recover rinses from tankers, tanks and lines. They reported that a 6000 gallon raw milk tanker normally was rinsed with 250 gallons of water and this rinse contained 9.10 pounds BOD5. An initial 30 gallon burst-rinse could recover 7.5 pounds BOD5. The rinse contained 1.5% butterfat and reduced the receiving process BOD5 coefficient by 0.05 pounds of BOD5/1000 pounds milk received. The fat content was observed to be 3.4% butterfat for high solids products or rinses from tank trucks which had sat over 1 hour before unloading.

Equipment Design and Process Modification

Plant areas, operations and equipment that contribute to water utilization, wastewater discharge and waste loads include conveying systems, casers and stackers, clarifiers and separators, high-temperature, short-time pasteurizers, cleaning systems (CIP), filling area, hose stations and cottage cheese processing areas.

A number of modifications in equipment and process design have been suggested to reduce current unavoidable losses of water and ingredients.

Current design of HTST systems require that they be started and stopped utilizing water. HTST start-up, changing from water to product and back to water, and the shut-down were the major sources of product losses to drain in the pasteurization process. About 60 gallons of product usually becomes diluted during each start-up, switch-over, or shut-down and is often dumped to the sewer. Also, as most plants start and stop pasteurizing units 2-3 times per day, then make about 6 changes a day, over 150 pounds of BOD5 would be generated (22).

Harper et al. (22) indicated that a HTST recycle system, as they proposed it, would save 44% of the BOD5 normally generated in the pasteurization process. The BOD5 coefficient would be reduced from 0.80 to 0.45 lb of BOD5 per 1000 lbs of milk processed. The recycle system would collect the diluted product-water mixtures during start-up, shut-down and product change-overs. Elliott (21) has reported on such an installation in a new California dairy plant.

Harper et al. (22) presented modern methods that eliminate intermediate process vats from the processing of fluid milk products. The system utilizes the centrifugal machine in the form of clarifier-separator in combination with the HTST system.

They pointed out that product change overs are made product-to-product with no discharge to the drain and the elimination of the intermediate vats saves product losses with a BOD5 of 0.2 pounds per 1000 pounds of milk processed. They note the losses associated with the intermediate tanks for higher viscosity products such as cream may be 3.0 pounds of BOD5 per 1000 pounds of milk processed (22).

Zall (56) explained how water valves on hoses and modifications of plumbing to convey water to places of use can reduce water use. The use of the hose valves was mentioned as being not possible with cold water-steam mixing tees. He recommended that a central water heating system be installed to supply hot water to the hose stations. Separate hoses and piping were recommended for steam needs (Zall, 56). MIF (34) also noted that much water is wasted from hoses that are left running. The use of shut-off valves on hoses was also supported.

The pressure of delivery to hose stations should be 15-20 psi (MIF, 34). They point out that a pressure regulator may be needed to reduce the pressure to the desired point. Higher pressures were described as not needed and water delivery increases with increasing pressures.

A general recommendation was made by MIF (34) that hose stations supply water at 115 degrees F. They noted that the needed wastewater temperature is controlled by the melting point of milk fat, which is 84 to 95 degrees F. The practice of mixing steam and cold water to provide hot water was considered to be both uneconomical and unsatisfactory. They concluded that the utilization of central hot water heating saves fuel and water and allows the use of less costly and lighter hoses.

Most dairy plants have supporting columns through the process area for economic reasons (56). He noted that these columns frequently have a hose station located on them.

Zall also emphasized that one cannot fault workers for not turning off water when valves are difficult or impossible to operate because of faulty maintenance, consequently allowing water to run needlessly. Also, changing needs for different temperature water were often not met because of the long walk to the hose control station. He recommended piping to be installed at each point in the plant where water is often required instead of using hoses for a supply source.

Elliott (20) examined a number of new practices in dairy processing that relate to wastewater. He explained how CIP cleaning and welded pipeline systems have helped to reduce water use waste load and helped to automate dairy processing.

He postulated that CIP cleaning was more efficient than hand cleaning and welded pipeline systems were not subject to leaks at joints.

He described the collection of milk-water mixtures for use in dairy products or for animal feeding. He observed that through the use of air operated valves, level controls and a timed flow element a dairy plant could collect product-water mixtures and intermixed products. He explained that both of these mixtures were not legal milk products. Also, he described how the first rinses from CIP circuits could be similarly collected. Both of these concepts have been used.

The filling area is another place to conserve water and prevent product wastes from going into the plant wastewater system. He concluded that a plant recovery system was desirable to collect product from defective or damaged cartons. Conveyor lubricant usage in the filling area should be controlled, as the lubricant contains about 25% hexane solubles.

Many plants were reported to have installed separators and clarifiers that automatically desludge. The automatic desludging feature requires water and flushes solid residues to the sewer. He concluded that the sludge should be collected.

The use of a water feed recovery system on a separator-clarifier. He reported that it saved 250 gallons per hour or 2500 gallons per day in a new, large dairy plant utilizing two separator-clarifiers (20).

Cottage cheese processing can contribute the largest waste loads from dairy processing. A system has been described for washing and cooling cottage cheese, creaming the curd and pumping it to the filler. Water use for the washer/cooler is 0.3 to 0.5 gallon/pound curd, which Carawan (14) states is less than 1/2 that required by conventional method.

Based on recent findings, major water savings can be achieved by:

1. Installing a water recycle-filtering system on case washers.

2. Installing automatic flow controls on CIP separators.

3. Installing automatic flow controls on the water feed system to ice cream stick novelty machines.

Other suggestions for water savings can be found in earlier reports(14,22,56).

APPENDIX 1. GLOSSARY

Activated Sludge: A process of waste treatment used to biologically degrade organic matter in a dilute water suspension. High-rate air diffusion through the liquor promotes the growth of bacterial and other zoogleal organisms which, acting on the organic matter in the presence of dissolved oxygen, produce a sludge floc.

Aeration: The bringing about of intimate contact betwen air and liquid by bubbling air through the liquid or by agitation of the liquid to promote surface absorption of air.

Aeration Tank: A tank in which sludge, sewage, or other liquid waste is aerated.

Aerobic Bacteria: Bacteria which require the presence of free (dissolved or molecular) oxygen for their metabolic processes. Oxygen in chemical combination will not support aerobic organisms.

Aerobic Decomposition: Reduction of the net energy level of organic matter by aerobic microorganisms.

Anaerobic Bacteria: Bacterias that do not require the presence of free or dissolved oxygen for metabolism. Strict anaerobes are hindered or completely blocked by the presence of dissolved oxygen and in some cases by the presence of highly oxidized substances such as sodium nitrates, nitrites, and perhaps sulfates. Facultative anaerobes can be active in the presence of dissolved oxygen but do not require its presence. See Aerobic Bacteria for comparison.

Anaerobic Decomposition: Reduction of the net energy level and change in chemical composition of organic matter caused by microorganisms in an anaerobic environment.

Bacteria: Primitive plants, generally free of pigment, which reproduce by dividing in one, two or three planes. They occur as single cells, chains, filaments, well-oriented groups of amorphous masses. Most bacteria do not require light, but a limited number are photosynthetic and draw upon light for energy. Most bacteria are heterotrophic (utilize organic matter for energy and for food growth materials), but a few are autotrophic and derive their bodily needs from inorganic materials.

BAT: Best available treatment. Level of treatment established by EPA.

BCT: Best conventional treatment. Level of treatment which is to be obtained for conventional pollutants.

BOD (Biochemical Oxygen Demand): An indirect measure of the concentration of biologically degradable material present in organic wastes. It is the amount of free oxygen utilized by aerobic organisms which are allowed to attach the organic matter in an aerobically maintained environment at specified temperature (20 C) for a specific time period (5 days). It is expressed in milligrams of oxygen utilized per liter of liquid waste volume (mg/l) or in milligrams of oxygen per kilogram of solids present (mg/kg = ppm = parts per million).

BOD5: Five day biochemical oxygen demand. The most common time period for the measurement of a BOD.

BODu: The ultimate biochemical oxygen demand. The highest value for the amount of oxygen needed to oxidize an organic waste.

Biological Oxidation: The process whereby, through the activity of living organisms in an aerobic environment, organic matter is converted to more biologically stable (less putrifiable) matter.

Biological Stabilization: Reduction in the net energy level of organic matter as a result of the metabolic activity of organisms; the tendency to purify.

Biological Treatment: Organic waste treatment in which bacterial and/or biochemical action is intensified under controlled conditions.

C/N, Carbon-Nitrate Ratio: The weight ratio of carbon to nitrogen.

Chemical Oxidation: Oxidation of organic substances without benefit of living organisms. Examples are by thermal combustion or by oxidizing agents such as chlorine.

Chlorine Contact: A detention basin where chlorine is diffused through the treated effluent which is held a required time to provide the necessary disinfection.

Churned Buttermilk: By-product resulting from the churning of cream into butter. It is largely defatted cream and its typical composition is 91% water, 4.5% lactose, 3.4% nitrogenous matter, 0.7% ash and 0.4% fat. Churned or "true" buttermilk is distinguished from cultured buttermilk, which is a fermentation product of skim milk. The latter is sold in the retail market and referred to simply as "buttermilk."

COD (Chemical Oxygen Demand): An indirect measure of the biochemical load exerted on the oxygen assets of a body of water when organic wastes are introduced into the water. It is determined by the amount of potassium dichromate consumed in a boiling mixture of chromic and sulfuric acids. The amount of oxidizable organic matter is proportional to the potassium dichromate consumed. Where the wastes contain only readily available organic bacterial food and no toxic matter, the COD values can be correlated with BOD values obtained from the same wastes.

Condensed: The term "condensed" as used in this report, applies to any liquid product which has been concentrated through removal of some of the water it normally contains, resulting in a product which is still in the liquid or semi-liquid state. When applied to milk, the term "condensed" is used interchangeably with "evaporate" to designate milk which has been concentrated. Commercially, however, the term "evaporated milk" is commonly used to define unsweetened concentrated milk.

Consumptive use: Portion of the gross water applied that is consumed or depleted - i.e., evaporated into the atmosphere or incorporated into the product itself.

Contamination: A general term signifying the introduction into water of microorganisms, chemical, organic or inorganic wastes, or sewage, which renders the water unfit for its intended use. See pollution.

Cost: That which must be given in order to acquire, produce or effect something. The price paid for a thing.

Cultured Products: Fermentation-type dairy products manufactured by inoculating different forms of milk with a bacterial culture. This designation includes yoghurt, cultured buttermilk, sour cream, and cultured cream cheese, among other products.

Design Waste Load: That waste load that is unavoidable and relates to the design of the plant and equipment. This includes material left on equipment surfaces, in pipe lines and deliberately wasted, such as in the start-up of an HTST unit.

Dissolved Oxygen: The oxygen dissolved in sewage, water, or other liquid usually expressed as milligrams per liter or as percent of saturation.

Efficiency: In engineering analyses, it is most commonly applied as a measure of the input which results in output of useful work. Efficiency in percent is obtained by dividing the output by the input and multiplying by 100. (Input = Output + loss).

Effluent: That which flows out from a space. The waste discharge(s) from the plant.

Endogenous: An auto oxidation of cellular material that takes place in the absence of assimilable organic material to furnish energy required for the replacement of worn-out components of protoplasm.

EPA: The Environmental Protection Agency. The Federal agency is sometimes referred to as such, but individual states may have an EPA. It is preferable to use U.S. Environmental Protection Agency (US EPA) when referring to the Federal agency.

Externality or External (dis)economy: An economic influence of one activity or another activity, with no cost to the activity causing the externality. Pollution is an external diseconomy when someone not connected to the pollution causing activity must suffer personal or economic loss as a result of the pollution, or must pay the cost of eliminating it with no recourse to those causing it.

Fat: As used in this study, fat will be used synonymously with butterfat.

Filtration: The process of passing a liquid through a porous medium for the removal of suspended or colloidal material contained in the influent liquid by a physical straining action. The trickling filter process used in wastewater treatment is a method of contacting dissolved and colloidal organic matter with biologically active aerobic slime growths, and is not a true filtration process.

FOG: Fats, Oils and Greases. See hexane solubles.

Food to Microorganism Ratio: An aeration tank loading parameter. Food may be expressed in pounds of suspended solids COD, or BOD5 added per day to the aeration tank, and microorganisms may be expressed as mixed liquor suspended solids (MLSS) or mixed liquor volatile suspended solids (MLVSS) in the aeration tank.

Gross Water Applied: Total quantity of water necessary to process a unit of raw material or to process a unit of output.

Hexane Solubles: The concentration of FOG recoverd from a sample of wastewater using the hexane distillation procedure.

Hydraulic Loading: The flow (volume per unit time) applied to the surface area of the clarification of biological reactor units or the wastewater flow from a process plant.

ICR: Industrial Cost Recovery. System of charges levied to recover from an industrial user of the wastewater treatment facilities the Federal grant amount, issued under Public Law 92-500, as amended, allocable to the construction of facilities for treatment of wastes from the industrial user. These charges are separate from and not a part of the wastewater treatment bill whose constituent element includes the user charge system and the billing and collection charge.

Ice Cream: Applied in a general sense, this term refers to any milk-based product sold as frozen food. Food regulatory agencies define ice cream in terms of composition, to distinguish the product from other frozen dessert-type products containing less milk-fat or none at all, such as **sherbet, water ices and Mellorine.**

Infiltration Rate: The rate at which water can enter the soil. Units are usually inches of water per day. See percolation.

Influent: Wastewater or other liquid - raw, or partially treated - flowing into a reservoir, basin, treatment process or treatment plant.

Lagoon: An all-inclusive term commonly given to a water impoundment in which organic wastes are stored or stabilized, or both. Lagoons may be described by the predominant biological characteristic (aerobic, anaerobic, or facultative), by location (indoor, outdoor), by position in a series (primary, secondary, or other) and by the organic material accepted (sewage, sludge, manure, or other).

Milk Equivalent: Quantity of milk (in pounds) to produce one **pound of product. The milk equivalents used were those given** by the U.S. Department of Agriculture, Statistical Bullein No. 362 "Conversion Factors and Weights and Measures for Agricultural Commodities and their Products."

Mixed Liquor: A mixture of activated sludge and wastewater undergoing activated sludge treatment in the aeration tank.

Municipal Bill: Local bill which represents the cost of water and the cost of wastewater treatment if the user discharges into the public owned treatment works. The cost of wastewater treatment may be based on the metered water supplied to the user and may contain a surcharge for excessive amounts of a pollutant. See surcharge.

NPDES: National Pollution Discharge Elimination System. Regulates the discharge of wastewaters to the navigable waters of the United States pursuant to Section 402 of Public Law 95-217, The Clean Water Act of 1977.

Optimization: Process of selecting the mix of activities, and the levels of these activities, which are optimum under the desired conditions - in this study, that mix which gives the maximum net revenue or least cost to the dairy plant.

Oxidation Lagoon or Pond: Synonymous with aerobic lagoon. See lagoon.

pH: The symbol for the logarithm of the reciprocal of the hydrogen ion concentration, expressed in mols per liter of a solution, and used to indicate an acid or alkaline condition. (pH 7 indicates neutral; less than 7 is acid, greater than 7 is basic.)

Percolation Rate: The rate, usually expressed as a velocity, at which water moves through saturated granular material. The term is also applied to quantity per unit of time of such movement, and has been used erroneously to designate infiltration rate.

Pollution: The presence in a body of water (or soil or air) of substances of such character and in such quantities that the natural quality of the body of water (or soil or air) is degraded so it impairs the water's usefulness or renders it offensive to the senses of sight, taste, or smell. Contamination may accompany pollution. In general, a public health hazard is created, but in some cases only economy of esthetics are involved, as when waste salt brines contaminate surface waters or when foul odors pollute the air.

Population Equivalent: The calculated human population which would normally contribute the same amount of BOD per day. A common base is 0.2 lb (90.7 g) of 5-day BOD per capita per day. A dairy producing 200 lb (90.7 kg) of BOD per day will have a population equivalent (PE) of 1,000.

Preventable Waste: Waste which can be avoided by proper operation. Generally refers to leaks, spills, spoiled products and from improperly operated equipment.

Process: A continuous and regular action or succession of actions, taking place or carried on in a definite manner.

Process Effluent (discharge): The volume of wastewater emerging from a particular use in the plant.

Putrefaction: A process of decomposition in which, as a consequence of the breakdown of proteins, end-products with offensive odors are formed.

Raw Milk: Milk as received from the farm or of standardized composition that has not been pasteurized or separated.

Raw Waste Load: Numerical value of any waste parameter that defines the characteristics of a plant effluent as it leaves the plant, before it is treated in any way.

Recirculation Rate: The rate of return of part of the effluent from a treatment process to the incoming flow.

Recycle: Use of water over and over again for the identical application whence it came (a method of reuse).

Sanitary Sewer System: A sewer intended to carry wastewater from homes, businesses and industries. Storm water runoff sometimes is collected and transported in a separate system of pipes.

Sedimentation Tank: A tank or basin in which a liquid (water, sewage, liquid manure) containing settleable suspended solids is retained for a sufficient time so part of the suspended solids settle out by gravity. The time interval that the liquid is retained in the tank is called detention period. In sewage treatment, the detention period is short enough to avoid putrefaction.

Septic Tank: A single-story settling tank in which the organic portion of the settled sludge is allowed to decompose anaerobically without removal or separation from the bulk of the carrier water flowing through the tank. Only partial liquefaction and gasification of the organic matter is accomplished, and eventually the decomposed solids will accumulate to the extent that solids removal is necessary.

Settleable Solids: Those suspended solids contained in sewage or wastewater that will separate by settling when the carrier liquid is held in quiescent condition for a specified time interval.

Sewage: Water after it has been fouled by various uses. From the standpoint of source, it may be a combination of the liquid or water-carried wastes from residences, business buildings, and institutions, together with those from industrial and agricultural establishments, and with such ground water, surface water, and storm water as may be present.

Sewerage System: The term "sewerage system" means any system, whether community, individual, publicly or privately owned, for the collection and disposal of sewage or industrial wastes of a liquid nature, or both including various devices for the treatment of such sewage or industrial wastes.

Sewer Use Ordinance: A legislative enactment of a municipality governing sewer discharge.

Skim Milk: In common usage, skim milk (also designated non-fat, defatted, or "fat-free" milk) from which fat has been separated as completely as commercially practicable. The maximum fat content is normally established by law and is typically 0.1% in the United States. There is also a common but not universal requirement that non-fat milk contain a minimum quantity of milk solids other than fat, typically 8.25%. In many states the meaning of the term skim milk is broadened to include milk that contains less fat than the legal minimum for whole milk, such as the low-fat sold in the retail market. The term skim milk used in this study refers to non-fat milk.

Sludge: The accumulated settled solids deposited from sewage or other wastes, raw or treated, in tanks or basins, and containing more or less water to form a semi-liquid mass.

SS: Suspended solids. Particles of solid matter in suspension in the effluent which can normally be removed by settling or filtration.

Standard Manufacturing Process (SMP): An operation or a series of operations which is essential to a process and/or which produces a waste load that is substantially different from that of an alternate method of performing the same process. The concept was developed in order to have a flexible "building block" means for characterizing the waste from any plant within an industry.

Standard Raw Waste Load (SRWL): That waste load that is unavoidable and associated with the design of the process (See Design Waste Load). Generally refers to a unit operation.

Storm Sewer System: A sewer intended to carry storm water runoff and other waters to the nearest surface waters.

Surcharge: A charge levied by a municipality for wastewaters of strengths greater than those defined as normal.

System: A group, set or aggregate of processing forming a connected or complex whole.

Total Product: Quantity of total production of all product produced and packaged for distribution.

Total Solids: The residue remaining when the water is evaporated away from a sample of water, sewage, other liquids, or semi-solid masses of material and the residue is then dried at a specified temperature (usually 103 C).

TSS: Total Suspended Solids.

Total Water Utilization Costs: All costs of obtaining, handling and disposing of water from intake to outlet.

Unavoidable Waste: That waste which can not be prevented. (See Design Waste Load).

User Charge: System of charges levied on users for the cost of operation and maintenance including replacement reserve requirements on new and old wastewater collection and treatment facilities.

Waste: Potentially polluting material which is discharged or disposed of from a plant directly to the environment or to a treatment facility which eliminates its undesirable polluting effect.

Waste Discharged: The amount (usually expressed as weight) of some residual substance, if any, which is suspended or dissolved in the plant effluent after treatment.

Waste Load: Numerical value of any waste parameter (such as BOD5, FOG, etc.) that serves to define the characteristics of a plant effluent.

Wastewater: Waste-containing water discharged from a plant. Used synonymously with "effluent" in this study.

Water Utilization (use): The totality of water and steam flows - including intake water and wastewater treatment - for all water uses within a production unit, from one or more points of intake through one or more points of discharge of the final effluent.

Whey: By-product in the manufacture of cheese which remains after separating the cheese curd from the rest of the milk used in the process. Whey resulting from the manufacture of natural cheese is termed "sweet whey" and its composition is somewhat different than "acid whey" resulting from the manufacture of cottage cheese.

Whole Milk: In its broad sense, the term whole milk refers to milk of composition such as produced by the cow. This **composition depends on many factors and is seasonal with fat** content typically ranging between 3.5% and 4.0%. The term whole milk is also used to designate market milk whose fat content has been standardized to conform to a regulatory definition, typically 3.5%.

Zoogleal Organisms: Organisms imbedded in a jelly-like matrix or film usually associated with activated sludge growths in sewage treatment facilities.

APPENDIX 2. COMPUTATIONS AND CALCULATIONS

A. PREDICTING DAIRY FOOD PLANT WASTE LOADS.

Case Study

Traditionally dairy food plants, handling fluid milk and ice cream, have relied on their Federal monthly market report to assess their product losses and have assumed that these are equivalent to their organic waste loads. The Federal Market Order permits a 2% product loss without payment of penalties and most plants feel that they are doing well if they achieve a reported loss of 1% for milk fat and/or skimmilk.

Analyses of COD and BOD in waste streams can be used to more accurately reflect true loss and the degree of **preventable losses can be estimated by using standard raw waste loads (SRWL) for good management practices. To utilize this approach a number of calculations must be made. In these** calculations, the following assumptions are made, based on industrial experiences.

(a) Product loss is in equivalent pounds of 3.5% fat milk with a BOD5 of a 100,000 mg per liter.

(b) An average of 90% of the BOD load of a dairy plant is derived from product losses.

On the basis of the pounds of BOD lost per hundred pounds of BOD processed (=/1000 # 3.5% milk or milk equivalent) values relating percent loss and BOD loss are as follows:

% Product Loss In Market Report	Lbs of BOD Lost/100 lbs of Processed BOD or (1000 lbs at 3.5% Milk Processed)
0.5	0.56
1.0	1.11
1.5	1.67
2.0	2.22
2.5	2.75

It is possible to make a predictive estimate of losses based on dairy production figures, a judgment of management efficiency and the assessment of waste loads for different levels of management and advanced technology. This procedure involves use of milk equivalents or calculation of the pounds of BOD5 processed; an assessment of management proficiency; and a calculation of expected waste loads for a given level of management efficiency.

Calculation of BOD Processed

The simplest approach is to use milk equivalent values to convert all products back to 3.5% milk. In this case, the pounds BOD processed = [(pounds of product) x (milk equivalent)] x 0.1 pound of BOD/pound of 3.5% milk.

Milk equivalents:

Skimmilk	0.72
2% Milk	0.82
3.25% Milk	0.87
3.50% Milk	1.00
Cottage cheese	6.30
Ice cream	2.70
Condensed milk	2.40
Dry whole milk	7.40
Dry skimmilk	11.00
Dried whey	18.00
Cheddar cheese	9.90
Butter	______

A more accurate approach for a multiple product plant is to calculate BOD from composition.

The following is an example of the calculations needed for a milk, ice cream and cottage cheese plant.

Milk:

(a) for 3.5% milk,
pounds of BOD5 = pounds of milk x 0.10
where BOD5 = 1,000,000 mg/l

(b) for mixed fluid products,
pounds of BOD5 = pounds of product x [(% fat x 0.9) + (% protein x 0.103 + % carbohydrate x 0.65)]
where # of BOD5/# of product = 0.9, 1.03, and 0.7 for fat, protein and carbohydrate, respectively.

Ice Cream:

(a) for 10% fat ice cream,
pounds of BOD5 = pounds of ice cream x 0.320
where BOD5 = 320,000 mg/l

(b) for frozen desserts of mixed composition,
pounds of BOD5 = pounds of product x [(% fat x 0.09 + (% protein x 0.103) + (% carbohydrate x 0.07))]

Cottage Cheese:

Cottage cheese is a blend of curd and cream dressing.

pounds of BOD5 processed = [(% curd/100) x # of BOD5 in skimmilk processed] + [(% dressing/100) x # of BOD5 in dressing]

pounds of BOD5 processed into curd = pounds of curd x (100/% yield of curd/100) x .072

where skimmilk = 72,000 mg/l BOD5; generally this would be pounds of curd x 0.4752

pounds of BOD5 from dressing = pounds of dressing x (% fat x 0.09) + (% protein x 0.103) + (% carbohydrates x 0.065)

The pounds of BOD processed into milk, ice cream, and cottage cheese are shown for a case study plant in Table 1 for 6 months during 1976. Milk was calculated as a 3.5% fat product, ice cream was calculated on the basis of 10% milk fat and cottage cheese was a blend of 55% curd and 45% dressing with 165,000 mg/l BOD5 x U.

Using data in Table 1, and coefficients in Table 2, total BOD for different levels of management were calculated and compared to total pounds of BOD based on the sewer bill and on the market report.

The daily BOD loss tabulations show that the values for the market report are generally about 1/5 to 1/4 of the losses calculated from the city sanitary report. This type of comparison is not unusual and generally market report losses are much less than those determined from actual measurement of losses. In this particular situation, the city sanitary report is based on a single period analysis of BOD and these values would probably be considered to be inaccurate. The city in making its survey, surveyed for one week and the analyses are based on time aliquot and not flow proportional aliquot samples.

Table 1. Pounds and Percentage of BOD Processed for Milk, Cottage Cheese, and Ice Cream Operations for the First Six Months of 1976.

Month	Milk		Ice Cream		Cottage Cheese	
	# BOD	% of Total	# BOD	% of Total	# BOD	% of Total
1	77,022	53	58,894	40	10,357	7
2	66,794	50	56,886	42	11,149	8
3	84,664	41	68,192	41	11,619	8
4	70,274	48	65,165	44	11,730	8
5	79,078	49	72,478	45	10,718	6
6	80,757	48	76,408	45	12,155	7

Table 2. BOD Coefficients Associated with Different Levels of Management

	Lbs of BOD Lost/100 lbs of BOD Processed			
			Cottage Cheese	
Level of Management	Milk	Ice Cream	Plus Whey*	Whey Excluded
Excellent	0.3-0.5	1.5	32	1.0
Good**	1.0	3.0	35.5	2.2
Average**	2.5	5.0	39.5	8.0

*1.32 x 76,000 mg/l skimmilk = 100,000 mg/l; 1320% skimmilk = 100 # BOD.

**The difference between this value and excellent = preventable wastes.

The calculations of estimated losses under different management levels and comparison to sewer losses provides a basis for assessment of the waste management for the plant and also gives a starting point for the development of a program of waste control. On sight surveys indicate that the level of waste management control is between good and average and is in agreement with the data in Table 3.

Table 3. Estimation of Daily BOD5 Losses by Various Methods (1976)

Month	Based on Market Report	Production Management Analyses** Excellent	Good	Average	Based on City Sewer Bill*
Jan.	2,708	4,250	6,375	9,044	7,640
Feb.	1,923	4,765	6,202	8,763	6,662
Mar.	1,190	5,115	7,566	10,713	8,129
Apr.	2,458	5,337	7,565	10,690	9,047
May	1,498	4,785	6,489	8,536	7,946
June	1,750	5,080	7,181	10,060	9,560

*Based on single survey of 7 days made in 1975; samples based on time composites (1539 mg/1) (considered to be low by about 25% on basis of testing method).

**Using coefficient in Table 2, including cottage cheese with whey included.

Further information can be obtained by calculating pounds of BOD expected per 100 pounds of BOD processed for different levels of management and the given mix of the three products. These are tabulated in Table 4 and the percentage of various products' predicted contribution to BOD at different levels of management are shown in Table 5. The contribution of whey decreases as management level changes from excellent to average.

Water usage is in Table 6. Water usage in an average milk-ice cream-cottage cheese plant is 444 gal/100 # BOD processed. In good plants it is about 250 gallons/100 # BOD5, an in the best plant it is 100 gallons/100 # BOD5. Cottage cheese cooking, cooling and washing requires about 200 gallons/100 # of BOD processed.

Table 4. Comparison of Waste Analysis on Predicted BOD Estimates/100 # of BOD Processed for Different Levels of Management.

		Overall # BOD/100 # of BOD Processed Based on Level of Good Management		
Month	Based on Sewer Bill	Excellent	Good	Average
1	5.1	2.87	4.22	6.1
2	4.9	3.44	4.6	6.5
3	4.9	3.44	4.6	6.5
4	6.1	3.40	4.6	6.5
5	4.9	2.84	4.0	5.8
6	5.7	3.16	4.3	6.2

1. (# BOD/100 # BOD from milk x % of total BOD/100) + (# BOD/100 # BOD from ice cream x % of total BOD/100) + (# BOD/100 # BOD from cottage cheese x % of total BOD/100) = overall # BOD/100 # BOD processed.

Table 5. Distribution of BOD for Different Products at Different Levels of Management.

Level of Management	% of BOD Milk	Ice Cream	Cottage Cheese*
Excellent	7	18	74
Good	11	27	62
Average	19	32	49

*Whey included.

Table 6. Wastewater Coefficient in Gallons/100 # BOD Processed.

Period	Total BOD Processed/Day	Total Waste Water/Day (Gal)	Gal/100 # BOD
1	148,273	595,238	401
2	134,830	519,048	385
3	164,476	633,333	385
4	147,169	704,762	385
5	162,274	619,048	479
6	169,323	650,715	384

This approach can be used to determine where the plant is in respect to waste control following the initial survey.

The steps to follow are:

1. Determine % of each product produced.
2. Calculate BOD (or COD) for each product.
3. Calculate total BOD processed.
4. Calculate an expected BOD (COD) loss/100 pounds of BOD processed from data in Table 2 and % of product processed.
5. Compare these figures to those obtained in the survey.
6. Differences between survey data and those for excellent management provide an index on the preventable waste in the plant.

B. CALCULATIONS.

BOD

A. Pounds of BOD based on sewer data

1. Need:
    - a. Volume of water in gallons
    - b. Conversion factor for changing gallons to pounds (8.34 #/gal)
    - c. BOD in mg/l
    - d. Conversion for mg/l to fraction % (1,000,000)

2. Calculation:
    gallons x 8.34 x mg BOD/1,000,000 = #'s of BOD

3. Example:

   a. Given 100,000 gallons at a BOD strength of 2000 mg/l
   b. # BOD = (100,000 x 8.34)x(2000/1,000,000) = 1668 #

B. Pounds of BOD based on Market report

1. Need:

   a. Pounds of skim milk
   b. BOD value for skim milk
      [(72,000 mg/l)/1,000,000] = 0.072
   c. Pounds of fat
   d. BOD value for fat
      [(900,000 mg/l)/1,000,000] = 0.90

2. Calculation:

   (pounds of skim milk)x(0.072) + (pounds of fat)x(0.9) = # of BOD

3. Example:

   a. Given 90,000 of skim lost; 4,000 of fat lost
   b. # BOD = (90,000)x(0.072) + (4,000)x(0.9) = 10,080 lbs of BOD lost

C. Pounds of BOD Based on Compositional Data

1. Needs:

   a. Pounds of protein
   b. Protein factor for BOD/pound (1.03)
   c. Pounds of fat
   d. Fat factor for BOD/pound (0.90)
   e. Pounds of carbohydrate
   f. Carbohydrate factor for BOD/pound (0.70)

2. Calculations:

   (pounds of protein)x(1.03) + (pounds of fat)x(0.9) + (pounds of carbohydrate)x(0.7) = pounds of BOD

3. Example:

   a. Given 100,000 pounds of milk with 3% protein, 4% fat and 5% lactose.
      NOTE: pound of fat = (# of product) x (0.04)

b. # BOD = (100,000)x(0.03)x(1.03) + (100,000)x (0.04)x(0.9) + (100,000)x(0.05)x(0.7) = 10,190 #'s of BOD

C. SURCHARGE CALCULATIONS

BOD5 Load Known: (a) Flow (gallons)
(b) Concentration (mg/l)

BOD5 Load (lbs) = [8.34x(Flow)]x[(Concentration)/ 1,000,000]

where: Monthly flow = 2,000,000 gal
Average Concentration = 3000 mg/l

BOD5 Load (lbs) = [8.34x(2,000,000)]x[(3,000)]/ 1,000,000]

BOD5 Load = 50040 lbs

Surcharge Bill Known: (a) BOD5 Load (lbs)
(b) Flow (gallons)
(c) Normal BOD5 Concentration (mg/l)
(d) BOD5 Surcharge Cost ($/1000 lb)

where: (a) 50040 lbs
(b) 2,000,000 gal
(c) 300 mg/l
(d) $80/1000 lbs BOD5 excess of normal

BOD5 Surcharge = BOD5 Surcharge Cost x(Excess BOD5 Load)

where excess BOD5 Load = (BOD5 Load - Normal BOD5 Load)

Normal BOD5 Load (lbs) = [8.34X(2,000,000)x(300)]/ 1,000,000

Normal BOD5 = 5004 lbs

Excess BOD load = 45036

BOD5 Surcharge = [[$80x(45036 lbs)]/1000 lbs]

BOD5 Surcharge = $3,602.88

Milk has a BOD5 of 100,000 mg/l (ppm). Thus, 1 lb milk = 0.1 lb BOD5.

A dairy employee who saves 10 gallons of milk a day may save his plant (86 lbs milk x $.12* + $0.05** x 8.6 lbs BOD5) x 250 days/ year = $2687.50.

A dairy employee who does not use 1,000 gallons of water (less than 10 minutes of a water hose running) a day may save his plant 1,000 gallons x 250 days/year x $0.60/1000 gal = $150. The value is not too mmuch, but it is 250,000 gallons of water - enough for a family of 4 for about 2 years.

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*Value of product
**Cost of waste treatment

D. YIELD CALCULATIONS FROM COD

Example for Ice Cream

Materials	lbs of product	lb COD/lb product	lbs COD processed	$/lb COD
Cream				
Milk				
Buttermilk powder				
Whey powder				
Condensed skim				
Egg yolk solids				
Starch				
Sucrose				
Corn syrup				
Fructose				
Chocolate				
Citric acid				
TOTAL				

COD is based on product analysis/lbs COD + lbs product x 1 COD/lb product

Yield calculations:

A. lbs of COD processed ________

B. lbs COD down the drain ________

C. lbs COD/100 lbs processed [A/(B/100)] ________

D. % loss + C x 100 ________

E. Yield = 100 - D ________

APPENDIX 3. RECORD FORMS FOR WATER AND WASTE CONTROL

	RECORD FORM	USE	PAGE
A.	Waste Management Control Inspection Form	Plant survey for problem areas	
B.	Maintenance Request	Reporting maintenance problems	
C.	Product Loss Report	All overflows, spills, major leaks, etc.	
D.	Daily Ingredient Loss Report	Reporting loss control	
E.	Raw Material Use Ice Cream & Novelties	Reporting, calculations	
F.	Daily Milk Loss Report	Loss control	
G.	Raw Materials Use Cottage Cheese	Reporting, calculations	
H.	Ingredient Use for Fluid Products	Reporting, calculations	
I.	Daily Ice Cream Loss Report	Loss control	
J.	Milk Operations Report	Management control	
K.	Total COD and Loss Report	Loss control	
L.	Waste Water Coefficients a) weekly b) monthly	Management control	
M.	HTST Performance Report	Water control, efficiency	
N.	Rinse Recovery Report	Reporting	
O.	Computer Summary Sheet	Management control	
P.	Weekly Waste Summary	Management control	

Q.	Manufacturing Work Sheet	Reporting
R.	Waste Strength Summary	Calculations, loss control
S.	Weekly Chemical Materials Utilization	Reporting loss control
T.	Water Utilization Report	Reporting, calculations
U.	Water Usage Summary	Reporting, management control
V.	Daily Stick Novelties loss report	Reporting, loss control
W.	Waste Discharge Work Sheet	Calculations, loss control

A. WASTE MANAGEMENT CONTROL INSPECTION FORM

Milk, Ice Cream and Cottage Cheese

Plant:__________________________ Location:________________

Date:___Time In___Time Out___Evaluated By__________

	Compliance Yes/No	Comments/ Recommendations
RECEIVING ROOM:		
Tankers - unloaded promptly	_	________________
No leaks from unloading pumps	_	________________
Pipe connections free from leaks	_	________________
Tankers completely drained before washing	_	________________
Unloading hose properly drained	_	________________
Air-blow system in proper operation	_	________________
CIP system operating properly, no leaks	_	________________
Burst Rinses recovered to raw silos	_	________________
RAW MILK STORAGE:		
Outlet valves free from leaks	_	________________
Connections free from leaks	_	________________
Air actuated valves free from leaks	_	________________
Sampler not leaking	_	________________
Unloading pumps free from leaks	_	________________

MILK PROCESSING AREA:

HTST #1:

Plate sections free from leaks _ ______________

TP, BP seals not leaking _ ______________

Homo seals not leaking _ ______________

Separator operating properly, no overflow and shooting properly timed _ ______________

Connections free from leaks _ ______________

No overflow of balance tank _ ______________

Valves free from leaks _ ______________

No excessive water usage _ ______________

HTST #2:

Plate Sections free from leaks_ ____________

TP, BP seals not leaking _ ____________

Homo seals not leaking _ ____________

Separator operating properly, no overflow; and shooting properly times _ ____________

Connections free from leaks _ ____________

No overflow of balance tank _ ____________

Valves free from leaks _ ____________

No excessive water usage _ ____________

HTST #3:

Plate sections free from leaks_ ____________

TP, BP seals not leaking _ ____________

Homo not leaking _ ____________

Separator operating properly, no overflow; and shooting properly timed _ ______________

Connections free from leaks _ ______________

No overflow of balance tank _ ______________

Valves free from leaks _ ______________

No excessive use of water _ ______________

CREAM PROCESSOR:

Plate sections free from leaks _ ______________

Pump seals free from leaks _ ______________

No freeze-up of plates _ ______________

Connections free of leaks _ ______________

No overflow of balance tank _ ______________

Valves free from leaks _ ______________

PASTEURIZED MILK STORAGE TANKS:

Outlet valves free from leaks _ ______________

Pumps free from leaks _ ______________

Connections free from leaks _ ______________

Dry ingredient spillage handled as solid waste _ ______________

MILK FILLING AREA:

Milk filler #1:

Filler valves free from leaks _ ______________

No foam overflow _ ______________

Line connections free from leaks _ ______________

Sealer/capper operating properly _ ______________

Drip shields in use _ ______________

Containers for damaged cartons in use _ ______________

Proper use of product recovery system _ ______________

Milk filler # 2:

Filler valves free from leaks _ ______________

No foam overflow _ ______________

Line connections free from leaks _ ______________

Sealer/capper free from leaks _ ______________

Drip shields in use _ ______________

Containers for damaged cartons in use _ ______________

Proper use of product recovery system _ ______________

Milk filler #3:

Filler valves free from leaks _ ______________

No foam overflow _ ______________

Line connnections free from leaks _ ______________

Sealer/capper operating properly _ ______________

Drip shields in use _ ______________

Containers for damaged cartons in use _ ______________

Proper use of product recovery system _ ______________

Milk filler #4:

Filler valves free from leaks _ ______________

No foam overflow _ ______________

Line connections free from leaks _ ______________

Sealer/capper operating properly _ ______________

Drip shields in use _ ______________

Containers for damaged products in use _ ______________

Proper use of product recovery system _ ______________

Milk filler #5:

Filler valves free from leaks _ ______________

No foam overflow _ ______________

Sealer/capper operating properly _ ______________

Drip shields in use _ ______________

Containers for damaged cartons in use _ ______________

Proper use of product recovery system _ ______________

Milk filler #6:

Filler valves free from leaks _ ______________

No foam overflow _ ______________

Sealer/capper operating properly _ ______________

Drip shield in use _ ______________

Container for damaged product in use _ ______________

Proper use of product recovery system _ ______________

MATERIAL HANDLING and MILK COOLERS:

Case washer operating properly_ ______________

No excessive water usage for case washer _ ____________

Case loaders operating properly, causing no spillage _ ____________

Case stackers operating properly, causing no spillage _ ____________

Conveyors operating properly, causing no spillage _ ____________

No leaks in cooler _ ____________

No loss of product in load out_ ____________

Dumpster not leaking _ ____________

ICE CREAM PROCESSING AREA:

Make-up tanks:

Valves free from leaks _ ____________

Pumps free from leaks _ ____________

Fittings free from leaks _ ____________

No overflow of tanks _ ____________

Blend Tank:

Valves free from leaks _ ____________

Pumps free from leaks _ ____________

Line connections free from leaks _ ____________

Ice Cream HTST:

Plate sections free from leaks_ ____________

TP, BP free from leaks _ ____________

Homo seals not leaking _ ____________

Connections free from leaks _ ____________

No overflow of balance tank _ ____________

Pasteurized Ice Cream Mix Storage Tanks:

Outlet valves free from leaks _ ______________

Pumps free from leaks _ ______________

Connections free from leaks _ ______________

Connecting lines free from leaks _ ______________

No overflow of tanks _ ______________

Air blowdown of lines operating properly _ ______________

Mix flavoring tanks:

Valves free from leaks _ ______________

No overflow of tanks _ ______________

Connecting lines free of leaks _ ______________

Ice Cream Freezers:

No leaks in valves or connecting lines _ ______________

No leaks in seals _ ______________

Supply pumps free from leaks _ ______________

Machines operating properly _ ______________

Ice Cream Packaging Machines:

No leaks in valves or lines _ ______________

Machines operating properly _ ______________

Ice cream collected during shut downs _ ______________

Ice cream on floor handled as solid waste _ ______________

Proper disposal of damaged cartons _ ______________

Dumpster not leaking product _ ______________

NOVELTY OPERATIONS:

Vita Line #1:

No overflow, foaming at filling area _ ______________

Sticks feeding properly _ ______________

No loss of novelties from holders _ ______________

Pumps free from leaks _ ______________

Supply lines free from leaks _ ______________

Float valve operating properly _ ______________

No excessive use of water _ ______________

Vita Line #2:

No overflow, foaming at filling area _ ______________

Sticks feeding properly _ ______________

No loss of novelties from holders _ ______________

Pumps free from leaks _ ______________

Valves free from leaks _ ______________

Supply lines free from leaks _ ______________

Float valve operating properly _ ______________

No excessive use of water _ ______________

Vita Line #3:

No overflow, foaming at filling area _ ______________

Sticks feeding properly _ ______________

No loss of novelties from holders _ ______________

Pumps free from leaks _ ______________

Valves free from leaks _ ______________

Supply lines free from leaks _ ______________

Float valve operating properly_ ______________

No excessive use of water _ ______________

Vita Line #4:

No overflow, foaming at filling area _ ______________

Sticks feeding properly _ ______________

No loss of novelties from holders _ ______________

Pumps free from leaks _ ______________

Valves free from leaks _ ______________

Supply lines free from leaks _ ______________

Float valve free from leaks _ ______________

No excessive use of water _ ______________

Novelty Packaging Machines:

Machine #1 operating properly, no losses _ ______________

Machine #2 operating properly, no losses _ ______________

Machine #3 operating properly, no losses _ ______________

Machine #4 operating properly, no losses _ ______________

COTTAGE CHEESE PROCESSING:

Processing:

Starter vat and fittings free from leaks _ ______________

Cream dressing tanks, valve and fittings free from leaks _ ______________

Lines and valves supplying cheese vats free from leaks _ ______________

Cheese vat properly filled _ ______________

Cheese vat valves free from leaks _ ______________

Whey excluded from drain _ ______________

Spilled curd handled as solid waste _ ______________

Packaging:

Lines and valves free from leaks _ ______________

Filler valves free from leaks _ ______________

Spilled product on floor handled as solid waste _ ______________

B. RESOURCES CONTROL PROGRAM

Maintenance Request

Note: This form is to facilitate maintenance and is to be filled out by the Foreman and can be initiated by the operator or Foreman.

DATE: ____________________

NO.: (To be filled in by Engineering Dept.)______________

INITIATED BY:________________ FOREMAN:____________________

AREA:____

EQUIPMENT:____

WHEN PROBLEM FIRST OBSERVED:______________________________

____

PROBLEM:____

____

____

____

SUGGESTED SOLUTION:____

____

____

____

ROUTING: (Initial and forward to Chief Engineer)

Production Supervisor ____________

Engineering Foreman ____________

Chief Engineer ____________

MAINTENANCE ORDER NO.:____________________

C. RESOURCES CONTROL PROGRAM

PRODUCT LOSS REPORT

NOTE: REPORT ANY MATERIAL, SUCH AS OVERFLOWS, DUMPED PRODUCT, MAJOR LEAKS, SPILLS, PACKAGED PRODUCT LOST, ETC.

DATE:________________ TIME:______________________________

LOCATION:____

PRODUCT LOST:____

ESTIMATED VOLUME LOSS:_____________________________________

DESCRIPTION OF PROBLEM (OVERFLOW, LEAKAGE, ETC):_________

____

____

____

CAUSE OF PROBLEM:____

____

____

RECOMMENDATIONS FOR CORRECTION:____________________________

____

____

____

D. RESOURCES CONTROL PROGRAM

DAILY INGREDIENT LOSS REPORT

INGREDIENT	TOTAL USED	TOTAL NOT ACCOUNTED FOR IN PRODUCT	% LOSS
Sucrose-milk			
Sucrose-ice cream			
Sucrose-novelty			
Corn syrup			
Whey powder			
Chocolate			
Condensed skim			
Non Fat Dry Milk			
Citric Acid			

E. RAW MATERIAL USE

ICE CREAM & NOVELTIES

CREAM __________ lbs. __________ fat

MILK __________ lbs. __________ fat

TOTAL B/FAT __________ lbs.

STD. B/FAT __________ lbs. __________ Difference

B.M. POWDER __________ lbs.

SUCROSE __________ lbs.

CORN SYRUP __________ lbs.

FRUCTOSE __________ lbs.

WHEY POWDER __________ lbs.

RINSE RECOVERY __________ lbs. MILK __________ lbs.

FAT __________ %

CHOCOLATE __________ lbs.

SALT __________ lbs.

CITRIC ACID __________ lbs.

6% STAB. SLURRY __________ lbs.

STARCH __________ lbs.

EGG YOLK SOLIDS __________ lbs.

COMMENTS:

F. DAILY MILK LOSS REPORT

DATE: ____________________

1. TOTAL POUNDS OF MILK RECEIVED ________________
2. TOTAL POUNDS OF FAT RECEIVED ________________
3. TOTAL POUNDS OF SKIM MILK RECEIVED _____________
4. TOTAL POUNDS OF MILK PROCESSED _______________
5. YIELD LOSS IN PROCESSING (POUNDS) _______ $_____
6. FAT LOSS IN PROCESSING (POUNDS) _______ $_____
7. SKIM MILK LOSS IN PROCESSING (POUNDS) _______ $_____
8. TOTAL POUNDS OF MILK PACKAGED _______ $_____
9. YIELD LOSS IN PACKAGING (POUNDS) _______ $_____
10. FAT LOSS IN PACKAGING (POUNDS) _______ $_____
11. SKIM MILK LOSS IN PACKAGING (POUNDS) _______ $_____
12. TOTAL NUMBER OF MILK CARTONS USED _______ $_____
13. TOTAL NUMBER OF MILK CARTONS LOST _______ $_____
14. TOTAL POUNDS OF MILK RECOVERED FROM PACKAGED PRODUCTS RECOVERY _______ $_____
15. TOTAL AMOUNT OF REPORTED SPILLAGE _______ $_____
16. TOTAL ESTIMATED LOSS (5+9+15-14) _______ $_____
17. TOTAL ESTIMATED FAT LOSS _______ $_____
18. TOTAL ESTIMATED SKIM MILK LOSS _______ $_____
19. ESTIMATED LOSS OF BOD FROM MILK OPERATIONS _______ $_____
20. MILK EQUIVALENT OF BOD LOSS _______ $_____
21. DIFFERENCE IN LOSS IN 16 AND 20 _______ $_____

G. RAW MATERIAL USE

COTTAGE CHEESE

	lbs.	COD/lb.	# COD
Skim milk to vats			
Starter			
Dressing			

A) COD processed ____________________

B) COD to drain from C. C. operation ____________

% loss (A/B x 100)

COD as fines _____________ lbs. curd _________

% curd loss as fines _________________

H. INGREDIENT USE FOR FLUID PRODUCTS

Date: ____________________________

	Gallons	Pounds
Total milk received	________	_______
Total milk processed	________	_______
Skim to CC	________	_______
Cream to CC	________	_______
Milk to IC	________	_______
Skim to IC	________	_______
Cream to IC	________	_______
# Sugar		_______
# Liquid corn		_______
# Fructose		_______
# Chocolate		_______
Orange juice		_______

I. RESOURCES CONTROL PROGRAM

DAILY ICE CREAM LOSS REPORT

1. TOTAL GALLONS OF MIX MADE ______ TOTAL POUNDS ______

2. TOTAL POUNDS OF FAT UTILIZED _______

3. TOTAL POUNDS OF MILK SOLID NOT FAT UTILIZED _______

4. TOTAL POUNDS OF SUGAR UTILIZED _______

5. TOTAL NUMBER OF PACKAGES USED _______

6. TOTAL NUMBER OF PACKAGES FILLED ________

7. TOTAL NUMBER OF PACKAGES LOST _______ $______

8. TOTAL GALLONS OF ICE CREAM PACKAGED ______
Total Pounds _______

9. TOTAL POUNDS OF ICE CREAM LOST _______ $______

10. POUNDS OF BOD FROM ICE CREAM LINE _________
Surcharge $______

11. POUNDS OF BOD CORRECTED FOR NOVELTY OPERATION _______
Surcharge $______

12. ESTIMATED ICE CREAM LOSS FROM BOD VALUE IN 11 _______
$______

13. DIFFERENCE BETWEEN 9 AND 12 _________________

Date: ____________

J. MILK OPERATIONS

DATE: ______________

Total Milk to Account for: ______________________

Total Milk Accounted for: ______________________

Milk to Ice Cream: ______________________

Cream to Ice Cream: ______________________

Skim Milk to Cottage Cheese: ______________________

Dressing to Cottage Cheese: ______________________

Total Cream Produced: ______________________

Total Skim Milk to Account for: ______________________

Total Skim Milk Accounted for: ______________________

Total Fat to Account for: ______________________

Total Fat Accounted for: ______________________

Total Chocolate powder used: ______________________

Total NFDM used: ______________________

Total sugar used: ______________________

Total corn syrup used: ______________________

Total fructose used: ______________________

Receiving Loss %: ______________________

Manufacturing Milk Loss %: ______________________

Manufacturing Skim Loss %: ______________________

Manufacturing Fat Loss %: ______________________

K. TOTAL COD

Date: ______________________

# COD from Ice Cream __________________

# Fructose ____________ # COD ___________ for Milk use

NFDM ____________ # COD ___________ for Milk use

Milk ____________ # COD ___________ for Milk use

Total COD _____________

# Milk = pounds milk received - pounds milk to ice cream - pounds cream to ice cream

% loss = [(# COD in Drain #3)/(total # COD)] x 100

L-a. WASTE WATER COEFFICIENTS - WEEKLY SUMMARY

Week ________________

COEFFICIENT	Daily Average							Weekly Average
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	
Gal Waste Water/1000 # Milk Processed								
Gal Waste Water from Ice Cream-Novelty Operation/1000 # of Product Processed								
Gal Waste Water from Hub Drains/1000 # Milk Processed								
Pounds COD/1000 # Milk Processed								
Pounds COD from Ice Cream-Novelty Operation/1000 # Product Processed								
Pounds COD from Hub Drains/1000 # Milk Processed								
Pounds BOD from Milk Operations/1000 # Milk Processed								

L-b. WASTE WATER COEFFICIENTS - MONTHLY SUMMURY

PERIOD: ____________________

COEFFICIENT	Weekly Average				% Change from Last Period	% Change for same Period in 1977
	first	second	third	fourth		
Gal Waste Water/1000 # Milk Processed						
Gal Waste Water from Ice Cream-Novelty Operation/1000 # of Product Processed						
Gal Waste Water from Hub Drains/1000 # Milk Processed						
Pounds COD/1000 # Milk Processed						
Pounds COD from Ice Cream-Novelty Operation/1000 # Product Processed						
Pounds COD from Hub Drains/1000 # Milk Processed						
Pounds BOD from Milk Operations/1000 # Milk Processed						

M. RESOURCES CONTROL PROGRAM

HTST PERFORMANCE REPORT

DATE: ____________________

HTST #1:

Volume of water discharged to drain:
12:00 a.m. - 6:00 p.m. ____________________

6:00 a.m. - 6:00 p.m. ____________________

Total for day ____________________

Volume of rinses made ____________________

No. of start-ups & shut-downs ____________________

HTST #2:

Volume of water discharged to drain:
12:00 a.m. - 6:00 a.m. ____________________

6:00 a.m. - 6:00 p.m. ____________________

Total for day ____________________

Volume of rinses made ____________________

No. of start-ups & shut-downs ____________________

HTST #3:

Volume of water discharged to drain:

12:00 a.m. - 6:00 a.m. ____________________

6:00 a.m. - 6:00 p.m. ____________________

Total for day ____________________

Volume of rinses made ____________________

No. of start-ups & shut-downs ____________________

HTST #4:

Volume of water discharged to drain:

12:00 a.m. - 6:00 a.m. ____________________

6:00 a.m. - 6:00 p.m. ____________________

Total for day ____________________

Volume of rinses made ____________________

No. of start-ups & shut downs ____________________

N. RESOURCES CONTROL PROGRAM

RINSE RECOVERY REPORT

DATE:________________________

VOLUME OF RINSES MADE:

	VOLUME ACCOUNTED FOR	NO. STARTS & STOPS	CALCULATED VOLUME TO DRAIN	VOLUME LOSS
HTST #1				
HTST #2				
HTST #3				
HTST #5				
TOTAL				

VOLUME OF PRODUCT RECOVERED FROM FILLERS:________________

RINSES SAVED:

VOLUME ______________ FAT TEST %

TOTAL SOLIDS ________% STANDARD PLATE COUNT ________/ml

COLIFORM COUNT _____/ml

Date:__________________

O. RESOURCES CONTROL PROGRAM

COMPUTER SUMMARY

Total gallons of water supplied ______

Total gallons of waste water discharged ______ $ ________________

Corrected for whey (-13,000 gallons) ______

Total gallons water consumed in plant ______ % of Total ________

Gallons waste water from Ice Cream ______ % ________________

Gallons waste water from Milk ______ % ________________

Gallons waste water from Hub Drains - CIP and Whey and wash water ______ % ________________

Water used for CIP (gallons) ______ % of Total Discharged ________

HTST water to drain - all units ______ % of Total Discharged ________

HTST water to drain (Milk) ______ % of Total Discharged ________

HTST water to drain (Ice Cream) ______ % of Total Discharged ________

Gal. waste water/ 100 # BOD into Ice Cream & Novelties ______

Rinses made ______

Rinses saved ______

Rinses discharged to drain ______

Milk recovered from filler ______

Total milk processed ______

Gallons waste water/

1000 # milk

P. WEEKLY SUMMARY OF WATER AND WASTE COEFFICIENTS

DATE:_____

DAY EQUIV- LOSS	1000# MILK PROC.	GAL WATER/ 1000# MILK	#BOD	#BOD/ 1000# MILK	DAILY $ SEWER	#MILK ALENT
MONDAY.						
TUES.						
WED.						
THURS.						
FRIDAY						
SAT.						
SUNDAY						
WEEKLY AVE.						

$ VALUE OF SEWER BILL AND PRODUCT LOSS FOR WEEK______:
PROJECTED YEARLY $ VALUE___________.

Q. MANUFACTURING WORK SHEET

ENTRY	DATE				
	Sunday-Monday	Tuesday	Wednesday	Thursday	Friday-Saturday
Total Milk to Account for					
Total Milk Accounted for					
Milk to Ice Cream					
Cream to Ice Cream					
Skimmilk to Cottage Cheese					
Dressing to Cottage Cheese					
Total Cream Produced					
Total Skimmilk to Account for					
Total Skimmilk Accounted for					
Total Fat to Account for					
Total Fat Accounted for					
Receiving Loss %					
Manufacturing Milk Loss %					
Manufacturing Skim Loss %					
Manufacturing Fat Loss %					

R. Waste Strength Summary

Date ____________

1. Total COD in waste water ________ pounds x .45 = ________ pounds BOD
2. Waste strength surcharge $ ________ for BOD $ ________ for SS
3. Contributors to COD:
    - a) Ice Cream and Novelties ________ pound COD x .45 = ________ pound BOD
    - b) Cottage Cheese ________ pound COD x .45 = ________ pounds BOD
    - c) Milk ________ pounds COD x .45 = ________ pounds BOD
4. Products Processed:
    - a) Milk ________ pounds
    - b) Ice cream gallons ________ x .45 = ________ pounds
    - c) Novelties units ________ x ________ pounds
    - d) Cottage cheese skimmilk gallons ________ x 8.6 = ________ pounds
    - e) Yield ________ pounds of cottage cheese curd ________
5. Waste Strength Coefficients:
    - a) Total ________ pounds BOD/1000 pounds milk equivalent processed
    - b) Ice Cream ________ pound BOD/1000 pounds milk equivalent processed

      ________ pound BOD/100 pounds BOD processed
    - c) Milk ________ pounds BOD/1000 pounds milk processed
    - d) Cottage cheese ________ pounds BOD/1000 pounds milk processed into cottage cheese
6. Product Losses (based on analyses):
    - a) Total BOD loss ________ 3.5% milk equivalent ________ $ ________ value
    - b) Milk Loss BOD ________ 3.5% milk equivalent ________ $ ________ value
    - c) Ice cream and novelty loss BOD ________ 3.5% milk equivalent ________

      stick loss ________ sugar loss ________

      calculated BOD to novelties ________ $ value of novelty losses

      Ice cream calculated share of BOD ________ mix equivalent ________

      $ value of ice cream loss ________

S. WEEKLY CHEMICAL MATERIALS UTILIZATION

DATES:______________________________

Material	Gal. used	Pounds used	BOD/# or gal	Total # BOD	COD/# or gal	Total # COD
LUBRICANTS						
CIP ACID						
CITRIC ACID						
CIP ALKALI 1						
CIP ALKALI 2						
CIP ALKALI 3						
CIP PHOSPHATE/ CHELATE						
CHLORINE -CIP						
CHLORINE -SANIT.						
SODIUM CHLORIDE						

T. RESOURCES CONTROL PROGRAM

WATER UTILIZATION REPORT

OPERATION	GALLONS DISCHARGED TO SEWER	GALLONS REQUIRED	PREVENTABLE LOSSES (GAL)	$
HTST #1				
HTST #2				
HTST #3				
HTST #5				
SEPARATORS				
VITA LINE #1				
VITALINE #2				
VITALINE #3				
VITALINE #4				
MILK FILLERS				
CASE WASHER				
CIP				
TOTAL TO SEWER				
ICE CREAM				
CC, CIP, HUB				
MILK				
ALL DEPARTMENTS				

U. WATER USAGE SUMMARY

Date ____________________

1. Total water supplied ______________ gallons x .42/1000 gal = $ ________ water bill

2. Total wastewater discharged ________ gallons x .45/1000 gal = $ ________ sewer charge

3. Total water consumed in plant _________ gallons % of total supplied __________

4. Contributors to wastewater volume

   a) whey ______________ gallons % of total wastewater ___________

   b) cheese wastewater ______________ gallons % of total wastewater ___________

   c) HTST units ______________ gallons % of total wastewater ___________

   d) CIP systems ______________ gallons % of total wastewater ___________

   e) Ice cream area ______________ gallons % of total wastewater ___________

5. a) Total milk received _____________ gallons ___________________ pounds

   b) Total milk processed _____________ gallons ___________________ pounds

   c) Total ice cream mix processed _____________ gallons ___________________ pounds

   d) Novelties processed _____________ units ___________________ pounds

6. Wastewater volume coefficient

   a) Total ______________ gallons wastewater/1000 pounds milk

   b) Ice cream drain ______________ gallons wastewater/1000 pounds milk equivalent

   c) HTST units ______________ gallons wastewater/1000 pounds milk equivalent

V. RESOURCES CONTROL PROGRAM

DAILY STICK NOVELTIES LOSS REPORT

1. TOTAL GALLONS OF MIX FOR STICK NOVELTIES PROCESSED ____________
2. CALCULATED NUMBER OF STICK NOVELTIES POSSIBLE FROM MIX ____________
3. NUMBER OF STICK NOVELTIES PACKAGED ____________
4. YIELD LOSS IN NUMBERS OF NOVELTIES ____________ $________
5. NUMBER OF STICKS NOT ACCOUNTED FOR ____________ $________
6. YIELD LOSS IN NUMBERS OF NOVELTIES ____________ $________
7. DIFFERENCE BETWEEN 4 and 6 ____________
8. ESTIMATED LOSS OF SUGAR (POUNDS) ____________ $________
9. ESTIMATED LOSS OF ACIDULANT (POUNDS) ____________ $________
10. ESTIMATED LOSS OF MILK SOLIDS ____________ $________
11. ESTIMATED LOSS OF BOD (POUNDS) ____________ $________
12. GALLONS OF WATER UTILIZED ____________ $________

TOTAL LOSS $________

W. RESOURCES CONTROL PROGRAM

WASTE DISCHARGES Work Sheet

1) Waste Volumes (gallons)

a) Ice Cream ______________ x 8.34 = ______________ pounds

b) Milk ______________ x 8.34 = ______________ pounds

c) Cottage Cheese Whey ______________ x 8.34 = ______________ pounds

d) Hub Drains ______________ x 8.34 = ______________ pounds

e) Total ______________ x 8.34 = ______________ pounds

2) COD Values (from analysis)

a) Ice Cream ______________ mg/l

b) Whey ______________ mg/l

c) Hub Drains ______________ mg/l

d) Total ______________ mg/l

3) BOD Values (pounds)

a) Ice Cream

$\frac{2a \times .46 \text{ (BOD/COD ratio)}}{1,000,000}$ x 1a (pounds) = ______________ # BOD

b) Whey

$\frac{2b \times .45}{1,000,000}$ x 2c (pounds) = ________________ # BOD

c) Hug Drains

$\frac{2c \times .45}{1,000,000}$ x 1d (pounds) = ________________ # BOD

d) Total

$\frac{2d \times .45}{1,000,000}$ x 1e (pounds) = ________________ # BOD

e) Milk

3d - (3a + 3c) = ______________ # BOD

4) % Contribution

a) Ice Cream

$\frac{3a}{3c} \times 100 =$ ______________ %

b) Whey

$\frac{3b}{3d} \times 100 =$ ____________ %

c) Hub Drains

$\frac{3c}{3d} \times 100 =$ ____________ %

d) Milk

$\frac{3d - (3a + 3c)}{3d} \times 100 =$ ________________ %

5) Coefficients

a) Total

$\frac{3d}{\text{\# milk processed/1000}} =$ _______________ # BOD/1000 # milk equivalent

b) Ice Cream

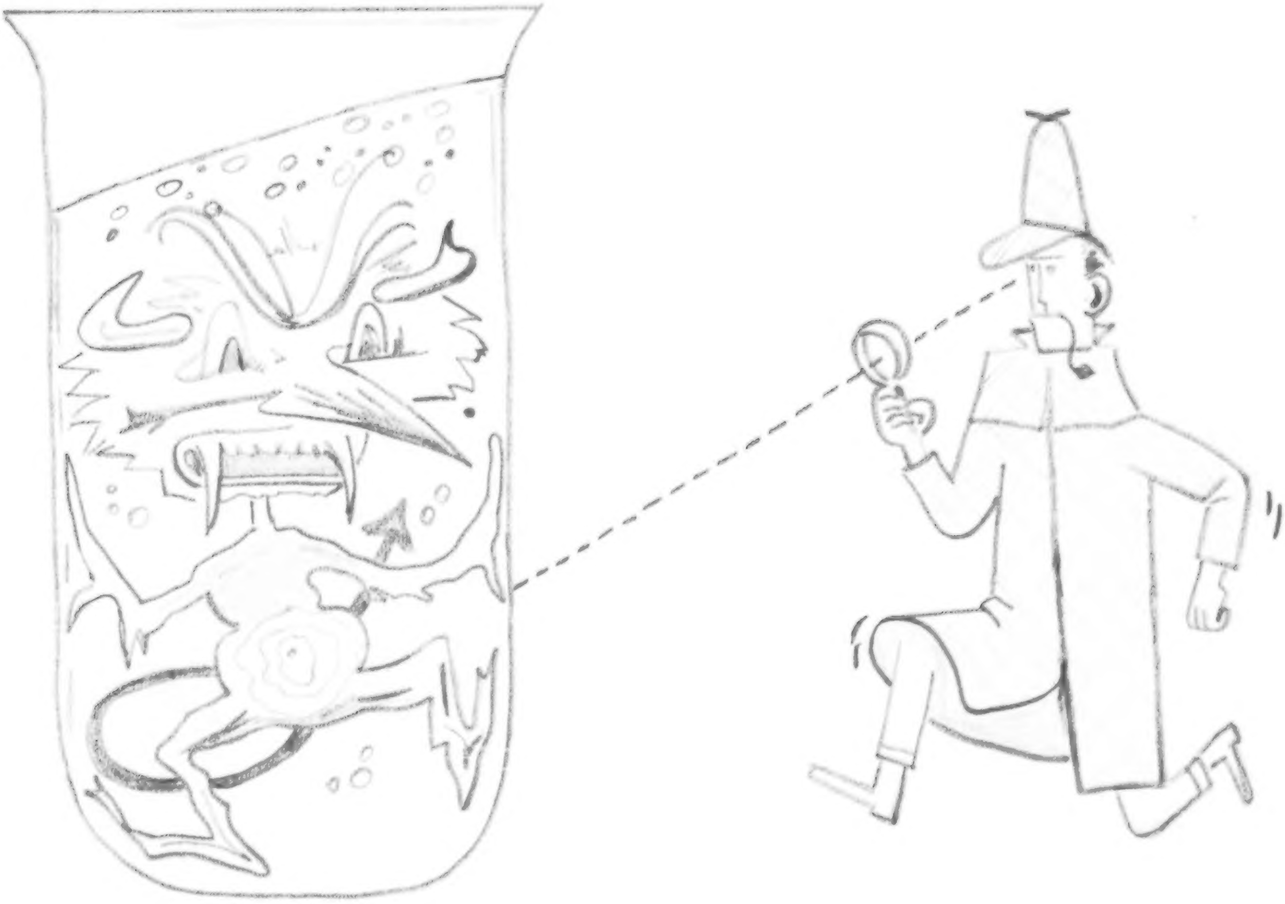
$\frac{3a}{\text{\# milk equivalent of ice cream + novelties/1000}} =$ _______________ # BOD/1000 # milk equivalent

c) Milk

$\frac{3d - (3a + 3c)}{\text{\# milk processed/1000}} =$ _______________ # BOD/1000 # milk equivalent

APPENDIX 4.SELECTED VISUAL AIDS FOR MANAGEMENT EDUCATIONAL PROGRAM

These materials were used as overhead projection transparencies for a portion of the management educational program and some were also used for the education presentation to plant employees. Copies are available upon request at cost of preparation.



TRACKING DOWN WASTES

CLASSIFICATION OF WASTES

UNAVOIDABLE FLUID WASTES:

THOSE WASTES LEFT ON THE SURFACES OF EQUIPMENT AND REMOVED BY CLEANING OPERATIONS. THE LEVEL OF UNAVOIDABLE LOSSES IS PRIMARILY A FUNCTION OF THE ENGINEERING DESIGN OF THE PLANT AND UNIT PROCESSES.

PREVENTABLE FLUID WASTES:

THOSE WASTES BEYOND THE DESIGN CAPACITY OF THE SYSTEM THAT RESULT FROM SPILLS, LEAKS, EQUIPMENT FAILURES, ETC. THE LEVEL OF THESE LOSSES RELATES DIRECTLY TO PLANT OPERATIONS AND CAN BE REDUCED THROUGH MANAGEMENT CONTROL.

WASTE PARAMETERS OF CONCERN

-BOD = BIOCHEMICAL OXYGEN DEMAND*
-COD = CHEMICAL OXYGEN DEMAND
-SS = SUSPENDED SOLIDS*
-FOG = FATS, OILS AND GREASE**
-PH = INDEX OF ACIDITY/ALKALINITY**
-P = PHOSPHOROUS
-N = NITROGEN
-V = VOLUME**

* THOSE PARAMETERS USED BY THE MUNICIPALITY IN CALCULATING THE MONTHLY SEWER USE CHARGE.

** THOSE PARAMETERS FOR WHICH THE MUNICIPALITY HAS SET LIMITS FOR DISCHARGE.

WASTE STRENGTH

BOD

BIOLOGICAL OXYGEN DEMAND

BOD_5 = OXYGEN IN PPM UTILIZED IN THE BIOLOGICAL (MICROBIAL) OXIDATION OF WASTES IN 5 DAYS

BOD_U = OXYGEN IN PPM UTILIZED FOR THE COMPLETE BIOLOGICAL (MICROBIAL) OXIDATION OF THE WASTES. ULTIMATE BIOLOGICAL OXYGEN DEMAND

COD

COD = OXYGEN IN PPM UTILIZED IN THE COMPLETE CHEMICAL OXIDATION OF THE ORGANIC CONSTITUENTS OF THE WASTES

COD IS APPROXIMATELY EQUIVALENT TO BOD_U

BOD = BIOLOGICAL OXYGEN DEMAND

= THE AMOUNT OF OXYGEN REQUIRED BY MICROORGANISMS IN 5 DAYS TO CONVERT FAT, PROTEIN AND CARBOHYDRATES TO MICROBIAL CELLS.

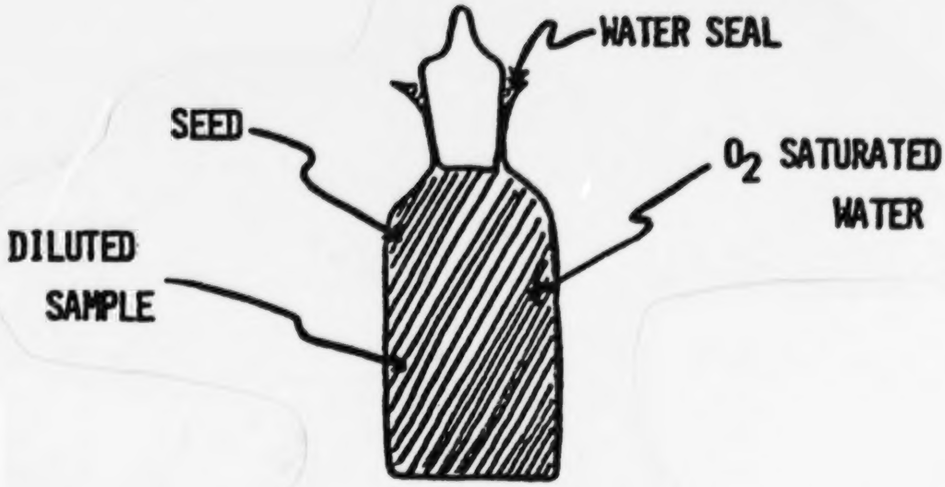
BOD_5 = BIOCHEMICAL OXYGEN DEMAND

BIOCHEMICAL OXYGEN DEMAND IS A MEASURE OF THE AMOUNT OF OXYGEN REQUIRED BY MICROORGANISMS TO ASSIMILATE ANY AVAILABLE NUTRIENTS IN A LIQUID WASTE INTO MICROBIAL CELLS IN 5 DAYS AT 20°C.

THE TEST IS OF AN EMPIRICAL NATURE AND DETERMINES THE REDUCTIONS IN DISSOLVED OXYGEN IN A CLOSED SYSTEM CONTAINING A SAMPLE OF WASTEWATER DILUTED WITH OXYGEN SATURATED WATER AND A SMALL QUANTITY OF SEED (CULTURE) CONTAINING ACCLIMATED MICROORGANISMS.

THE BOD OF THE DAIRY WASTE IS ABOUT 2000 MG/L, COMPARED TO 200-300 MG/L FOR DOMESTIC WASTE.

BOD


WATER SEAL
SEED
O_2 SATURATED WATER
DILUTED SAMPLE

O_2 MEASURED AT ZERO DAY

SAMPLE INCUBATED AT 21°C FOR 5 DAYS

O_2 MEASURED AFTER 5 DAYS

DIFFERENCE IN O_2 = OXYGEN CONSUMED

BOD = OXYGEN CONSUMED X DILUTION FACTOR

FOG = FATS, OILS AND GREASE

FOG IS THE MATERIAL EXTRACTED FROM FLUID WASTES BY HEXANE, FREON OR OTHER NON-AQUEOUS SOLVENT. FOG IS COMPOSED OF FREE AND EMULSIFIED FOOD LIPIDS, LUBRICANTS AND PETROLEUM-BASED OILS AND GREASE.

THE DAIRY WASTE HAS ABOUT 200 MG/L FOG AS COMPARED TO DOMESTIC WASTE, WITH ABOUT 100 MG/L FOG.

FOG IS LIMITED BY MANY MUNICIPALITIES TO 100 MG/L.

SS = SUSPENDED SOLIDS

SUSPENDED SOLIDS ARE THOSE THAT ARE RETAINED ON A STANDARD GLASS FIBER FILTER PAD AFTER FILTRATION. THE RESIDUE IS DRIED AT 104°C FOR ONE HOUR. SS CONTRIBUTE TO THE SLUDGE REMOVED BY PHYSICAL AND PHYSICAL-CHEMICAL MEANS IN THE PRIMARY TREATMENT FACILITY OF THE MUNICIPAL TREATMENT FACILITY.

SUSPENDED SOLIDS OF THE DAIRY WASTE ARE ABOUT 600 MG/L AS COMPARED TO 200-300 MG/L FOR DOMESTIC WASTE.

COD = CHEMICAL OXYGEN DEMAND

CHEMICAL OXYGEN DEMAND IS A MEASURE OF THE AMOUNT OF OXYGEN REQUIRED TO OXIDIZE THE ORGANIC MATTER IN A SAMPLE BY MEANS OF A STRONG CHEMICAL OXIDANT.

THE TEST UTILIZES A REFLUXED BOILING FOR TWO HOURS OF THE SAMPLE WITH A KNOWN AMOUNT OF POTASSIUM DICHROMATE AND SULFURIC ACID. THE EXCESS DICHROMATE IS TITRATED WITH A SOLUTION OF Fe AMMONIUM SULFATE. THE AMOUNT OF OXIDIZABLE ORGANIC MATTER, MEASURED AS THE OXYGEN EQUIVALENT, IS PROPORTIONAL TO THE DICHROMATE CONSUMED. THE METHOD TAKES ONLY A FEW HOURS, COMPARED TO FIVE DAYS FOR THE BOD TEST.

COD IS EQUIVALENT TO THE ULTIMATE BOD. THE COD OF THE DAIRY WASTE IS ABOUT 4200 mg/l COMPARED TO ABOUT 400-500 mg/l FOR DOMESTIC WASTES. THE BOD/COD RATIO OF THE DAIRY WASTE IS ABOUT 0.45.

BOD / COD RELATIONSHIPS

SAMPLE	BOD_5 AS % OF COD
WHOLE MILK	69
SKIMMILK	63
WHEY	52
dairy PLANT WASTES	
RAW	45
TREATED	20

RAW DAIRY PLANT WASTES RANGED FROM 0.10 - 0.90 BOD/COD OR 10-90%

TREATED DAIRY PLANT WASTES RANGED FROM 10 -30%

THE LOWER THE BOD AS % OF COD THE POORER IS THE BIOLOGICAL TREATMENT OF THE WASTE.

NORMAL COMPOSITION OF DOMESTIC WASTE

BOD	200 - 300 ppm
COD	250 - 370 ppm
SS	50 - 200 ppm
HEXANE SOLUBLES	100 ppm
phenols	0.5 ppm

COMPOSITION OF DAIRY FOOD PLANT WASTE WATER

	ppm	
	Range	Average
BOD	15 - 4790	1885
Suspended Solids	25 - 5700	834
Volatile Suspended Solids	17 - 5260	188
Volatile Total Solids	57 - 4700	1497
Total Solids	135 - 8500	2397

BOD OF FOOD COMPONENTS ARE DIFFERENT

COMPONENT	BOD (#/# OF PRODUCT)
MILK FAT	0.9
MILK PROTEIN	1.03
LACTOSE	0.65
SUCROSE	0.70
GUMS	0.2-0.4
CITRIC ACID	0.6

INDIANAPOLIS SEWER CHARGE STRUCTURE

VOLUME	$0.42/1000 GALLONS
VOLUME SERVICE CHARGES	$0.03/1000 GALLONS
	$0.45/1000 GALLONS
BOD OVER 200 MG/L	$0.026/POUND
SS OVER 250 MG/L	$0.45/POUND

WASTE COEFFICIENTS

WASTE WATER VOLUME:

POUNDS OF WASTE WATER / POUND OF MILK PROCESSED

POUNDS OF WASTE WATER = GALLONS X 8.3

WASTE WATER STRENGTH:

STRENGTH COEFFICIENTS TAKE INTO CONSIDERATION BOTH CONCENTRATION PER UNIT VOLUME AND VOLUME OF WASTE WATER.

BOD COEFFICIENT = POUNDS OF BOD / 1000 POUNDS OF MILK PROCESSED

$$\text{POUNDS OF BOD} = \frac{\text{PPM BOD} \times \text{GALLONS} \times 8.3}{1,000,000}$$

EXAMPLE OF UNAVOIDABLE/PREVENTABLE WASTES

FLUID MILK OPERATIONS:

	POUNDS BOD/1000 POUNDS MILK
1977 BOD LOSSES	1.57
UNAVOIDABLE LOSS DESIGN	0.50
PREVENTABLE LOSSES IN MILK DEPARTMENT	1.27

ECONOMICAL IMPACT OF MILK DEPARTMENT PREVENTABLE LOSSES

COEFFICIENT OF PREVENTABLE WASTES 1.25 # BOD

CONVERSION TO MILK EQUIVALENT (3.5%) 10.27 #

BASED ON MILK PROCESSES 1/13/77 = 1,430,472

POUNDS OF PREVENTABLE BOD LOST = 1,817 POUNDS

POUNDS PREVENTABLE MILK LOST = 18,170 POUNDS

COST FOR BOD DISCHARGED = $43.60

COST OF LOST MILK = $16,665.20

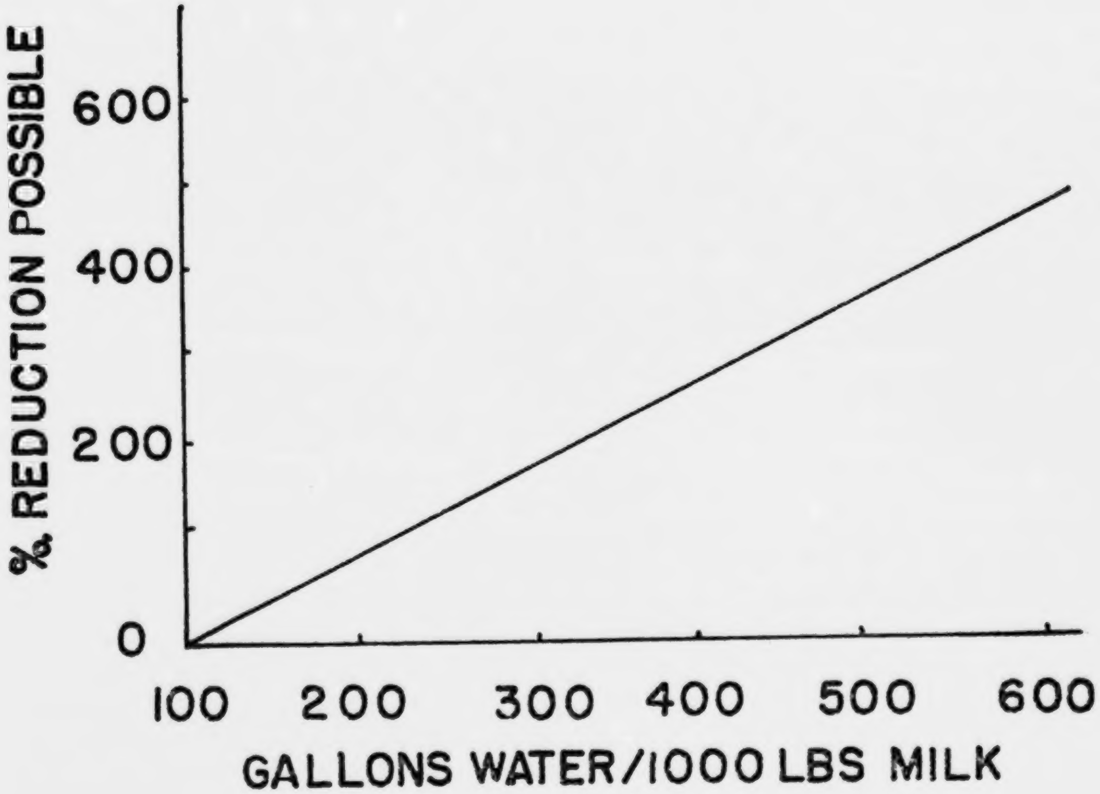
TOTAL COST = $1,708.80

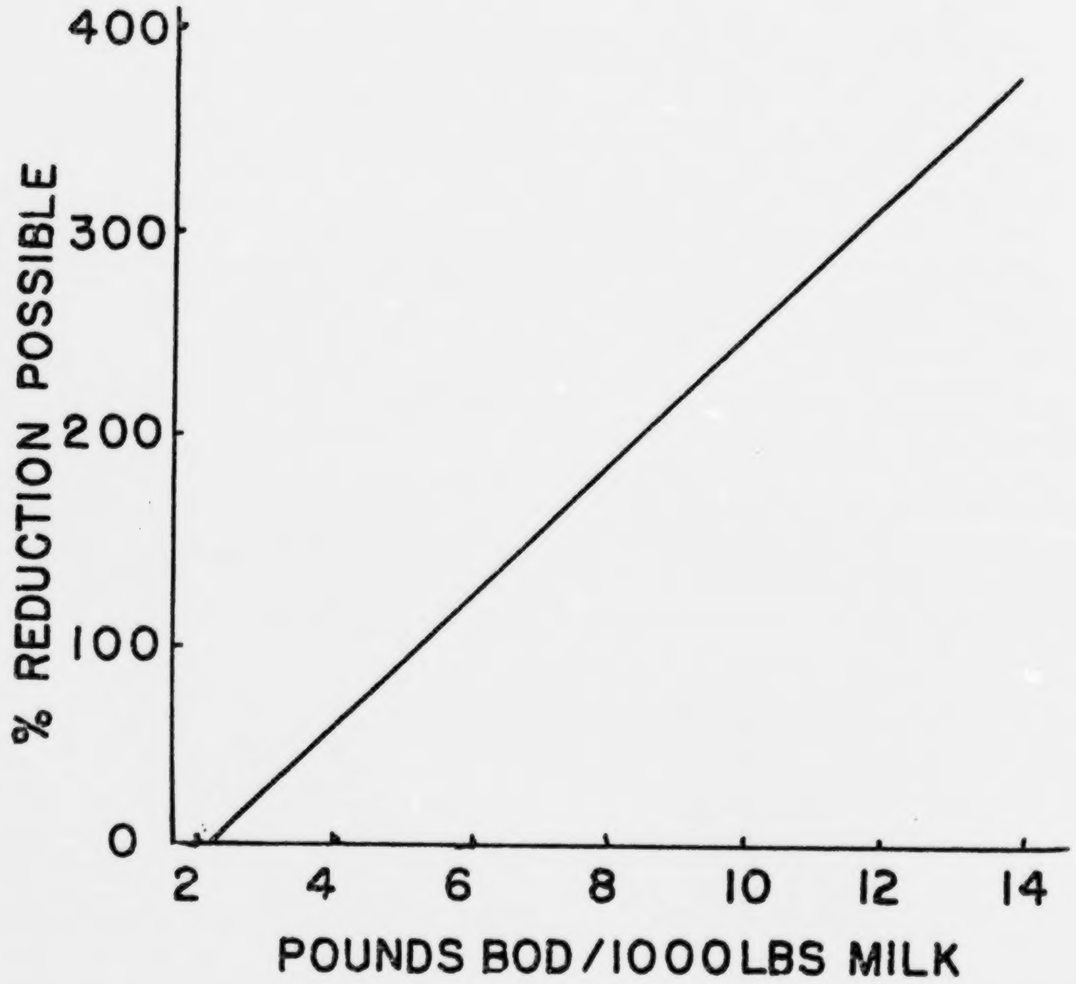
PROJECTED LOSS FOR ONE PERIOD = $34,176

COSTS ASSOCIATED WITH ICE CREAM (ACTUAL)

NO NOVELTIES

	% OF COST	COST/GALLON	COST/YEAR
TOTAL	100	.05	420,222
RM LOSS	5.1	.0002	18,980
FM LOSS	4.0	.0022	17,420
IC LOSS	46.3	.030	236,600
WATER	6.4	.0034	27,040
SAN. SEWER	6.4	.0034	26,780
BOD	2.5	.0014	10,660
SS	1.5	.0008	6,260
ENERGY	0.9	.0009	3,666
LABOR	17.3	.0093	73,060

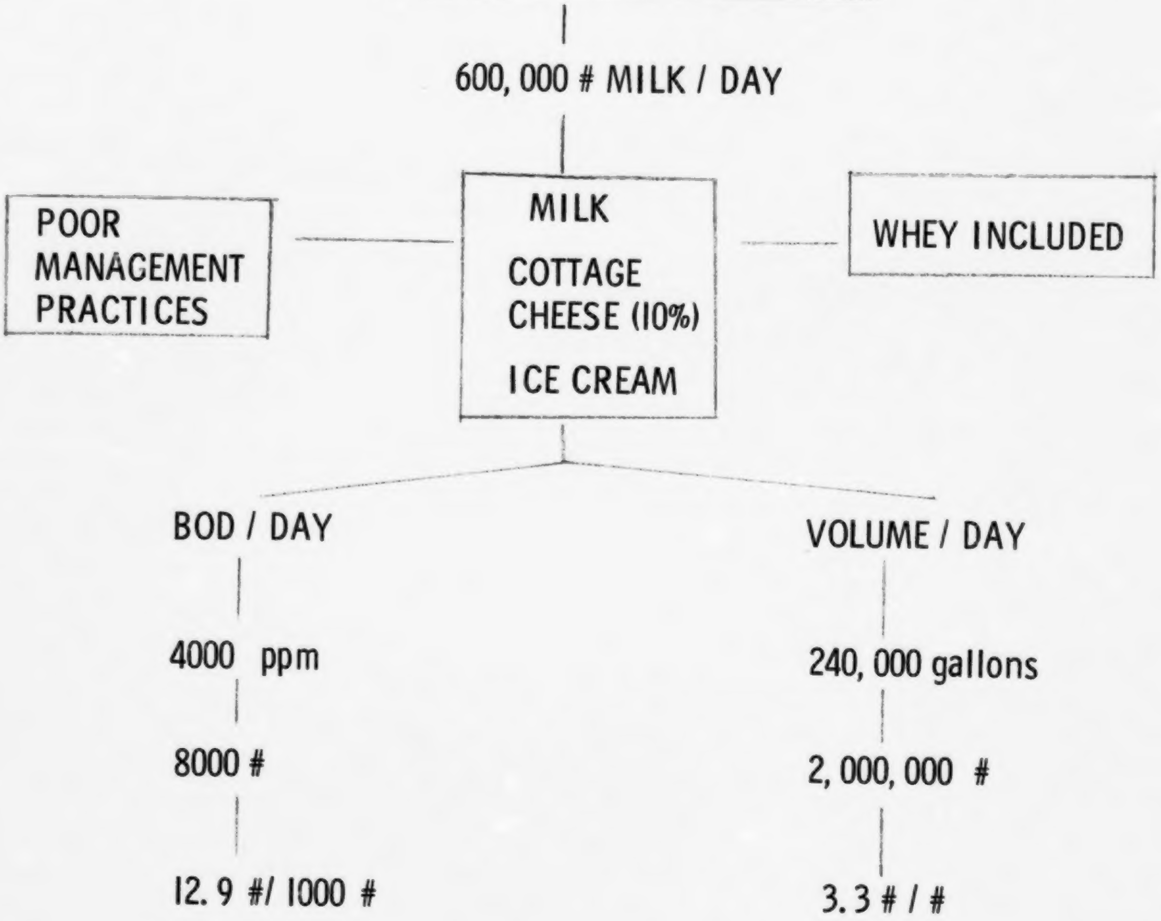

% REDUCTION POSSIBLE
600
400
200
0
100
200
300
400
500
600
GALLONS WATER/1000 LBS MILK



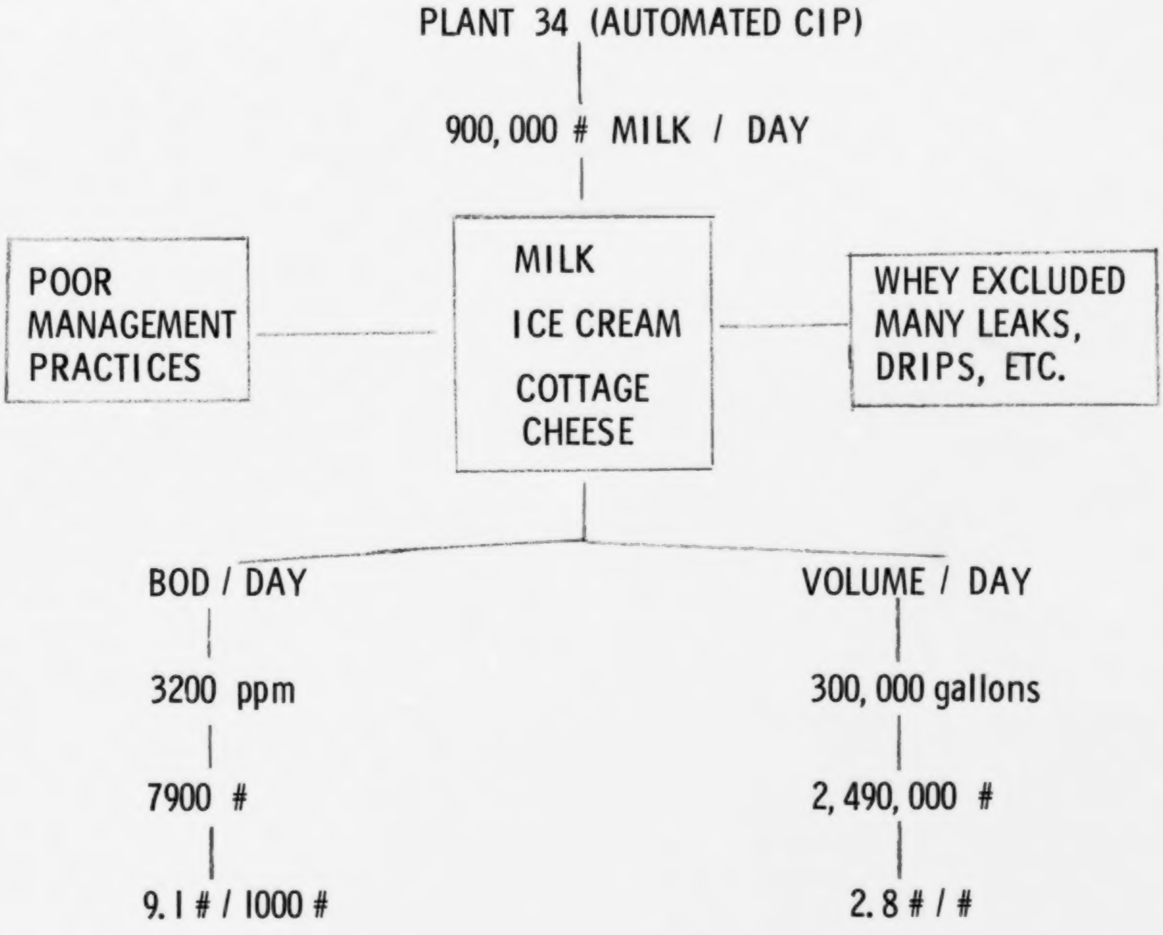
400
300
200
100
0
% REDUCTION POSSIBLE
2
4
6
8
10
12
14
POUNDS BOD/1000 LBS MILK

MILK + ICE CREAM + COTTAGE CHEESE

PLANT 33 (AUTOMATED CIP)


600, 000 # MILK / DAY
POOR MANAGEMENT PRACTICES
MILK
COTTAGE CHEESE (10%)
ICE CREAM
WHEY INCLUDED
BOD / DAY
4000 ppm
8000 #
12. 9 #/ 1000 #
VOLUME / DAY
240, 000 gallons
2, 000, 000 #
3. 3 # / #

MILK + ICE CREAM + COTTAGE CHEESE



PLANT 34 (AUTOMATED CIP)

900, 000 # MILK / DAY

POOR MANAGEMENT PRACTICES

MILK
ICE CREAM
COTTAGE CHEESE

WHEY EXCLUDED
MANY LEAKS,
DRIPS, ETC.

BOD / DAY

3200 ppm

7900 #

9. 1 # / 1000 #

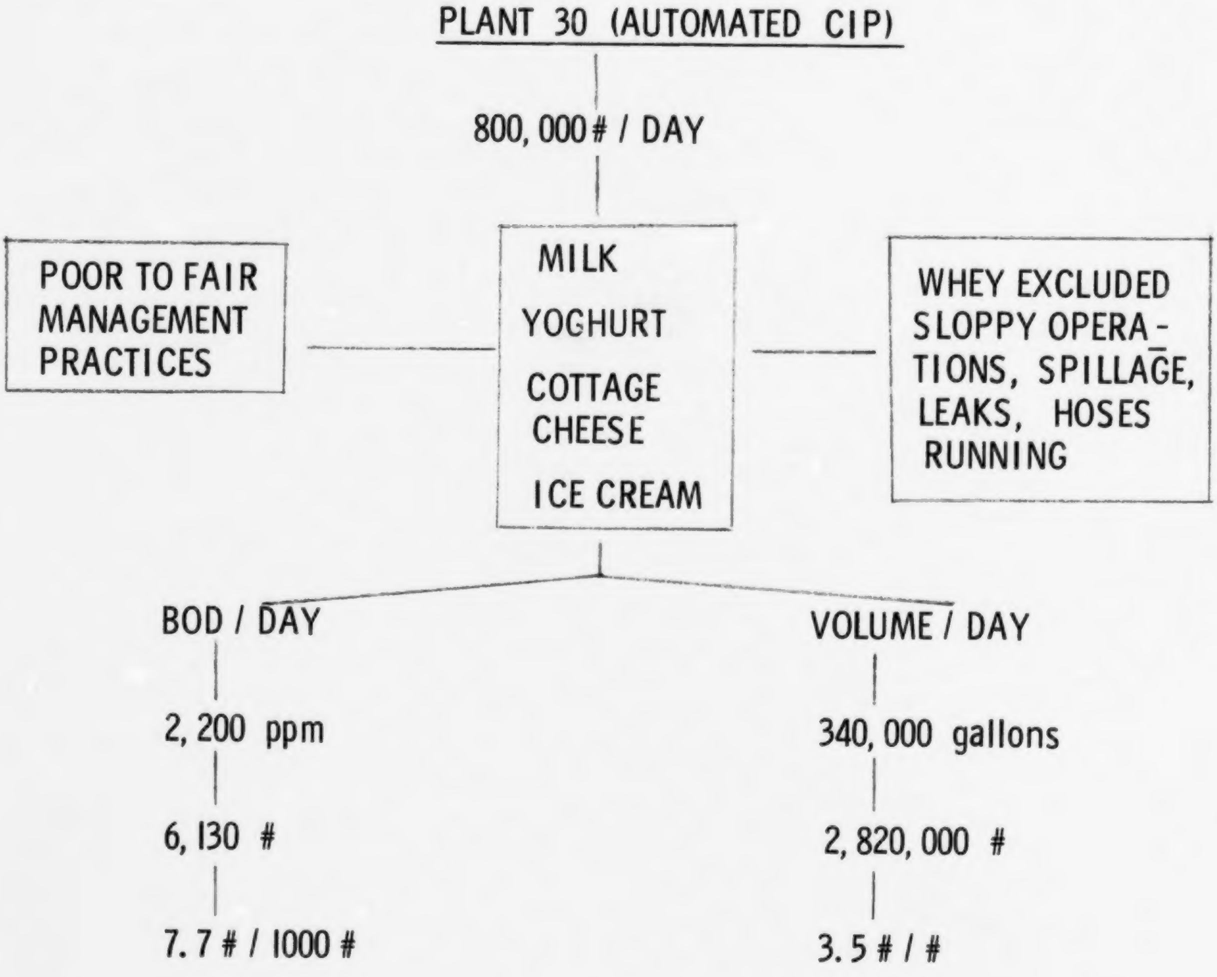
VOLUME / DAY

300, 000 gallons

2, 490, 000 #

2. 8 # / #

MILK + ICE CREAM + COTTAGE CHEESE



PLANT 30 (AUTOMATED CIP)

800,000 # / DAY

MILK
YOGHURT
COTTAGE CHEESE
ICE CREAM

POOR TO FAIR MANAGEMENT PRACTICES

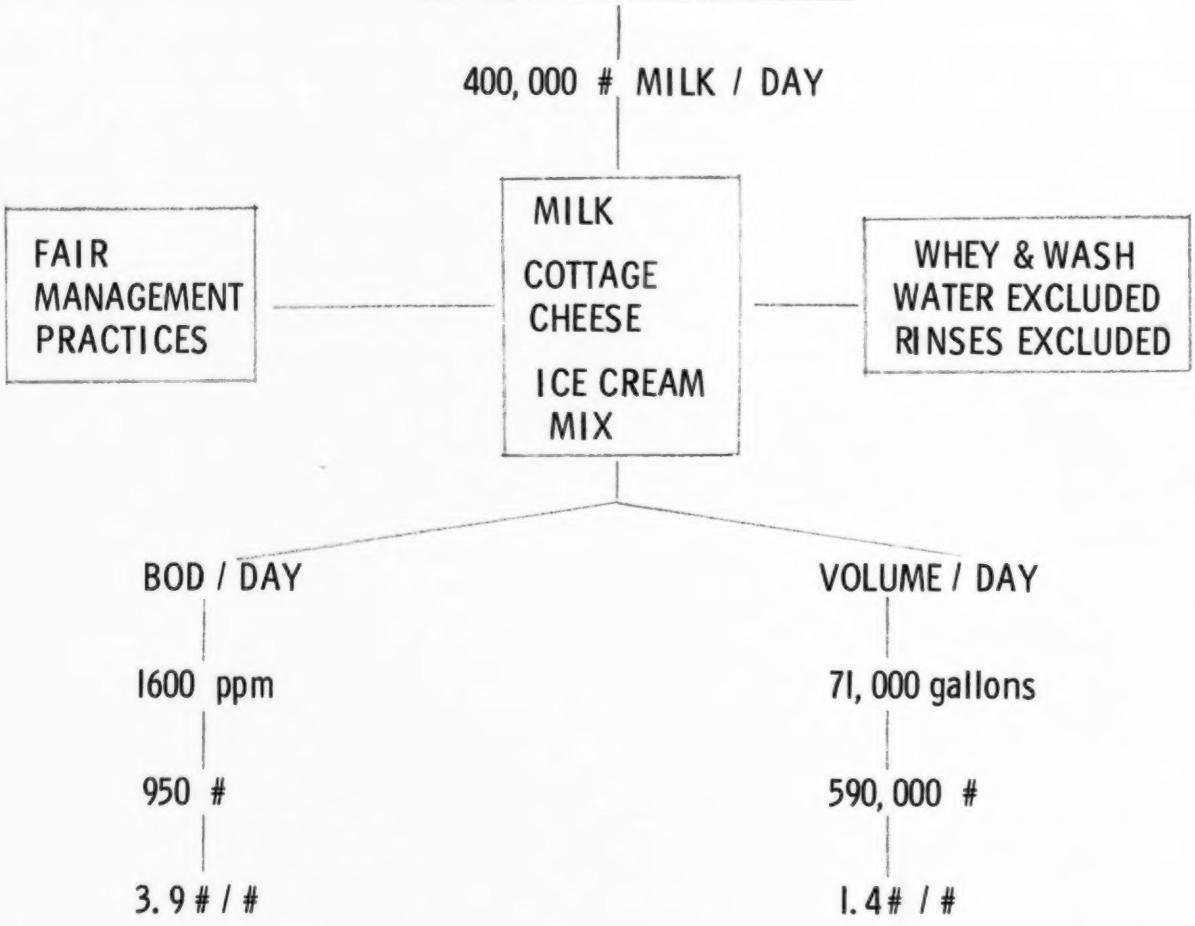
WHEY EXCLUDED
SLOPPY OPERATIONS, SPILLAGE, LEAKS, HOSES RUNNING

BOD / DAY
2,200 ppm
6,130 #
7.7 # / 1000 #

VOLUME / DAY
340,000 gallons
2,820,000 #
3.5 # / #

MILK + ICE CREAM + COTTAGE CHEESE

PLANT 3 (AUTOMATED CIP)


400,000 # MILK / DAY
FAIR MANAGEMENT PRACTICES
MILK
COTTAGE CHEESE
ICE CREAM MIX
WHEY & WASH WATER EXCLUDED RINSES EXCLUDED
BOD / DAY
1600 ppm
950 #
3.9 # / #
VOLUME / DAY
71,000 gallons
590,000 #
1.4# / #

WASTE LOADS FOR UNIT OPERATIONS UNDER GOOD MANAGEMENT PRACTICES

RAW MILK

OPERATION	POUNDS BOD/100 POUNDS BOD PROCESSED
RECEIVING MILK IN CANS AND COOLING	0.3
RECEIVING MILK IN TANK TRUCKS	0.2
STORAGE IN HORIZONTAL TANKS	0.1
STORAGE IN SILO TANKS	0.2
STORAGE IN CONE SHAPED SILO TANKS	0.05 (ESTIMATED)
STANDARDIZING RAW MILK (CIP SEPARATOR)	0.1
SHIPPING MILK IN TANK TRUCKS	0.1

CREAM

CREAM SEPARATING	0.2
CREAM PASTEURIZING AND COOLING (VAT)	0.3
CREAM PACKAGING	0.3

WASTE COEFFICIENTS

COTTAGE CHEESE

OPERATION	UNITS/1000# MILK PROCESSED	
	GAL	#BOD
WHEY	100	25
FIRST WASH	80	6-8
SECOND WASH	60	1-2
THIRD WASH	40	0.1-0.3
FINES	-	0.1-1.0

ICE CREAM

WASTE COEFFICIENTS FOR GOOD MANAGEMENT PRACTICES

OPERATION	BOD/100 # BOD PROCESSED
PASTEURIZATION	0.8
PASTEURIZATION WITH RINSE RECOVERY	0.10
COOLING AND STORAGE	0.2
FLAVORING AND NUTS	0.1
FREEZING	0.5
FILLING AND CONVEYING	0.2
TOTAL*	1.8

*PASTEURIZATION COEFFICIENT = 0.8

PREVENTATIVE MAINTENANCE - A MUST!!

A GOOD PREVENTATIVE MAINTENANCE PROGRAM CAN REDUCE PRODUCT LOSSES BY 50%

PREVENTATIVE MAINTENANCE INCLUDES:

REGULARLY INSPECT WATER HOSE STATIONS TO INSURE NO LEAKAGE OF SHUT-OFF VALVES OR SUPPLY LINES, VALVES, AND FITTINGS.

ALL MANUAL AND CIP FITTINGS SHOULD BE OF A DESIGN TO MINIMIZE LEAKAGE. GASKETS SHOULD BE INSPECTED AND REPLACED ON A REGULAR BASIS AS NEEDED.

ALL HAND OPERATED VALVES SHOULD BE IN GOOD CONDITION AND REGROUND WHENEVER NECESSARY.

STORAGE TANK OUTLET VALVES SHOULD BE IN GOOD CONDITION AND REGROUND AS REQUIRED.

PUMP SEALS SHOULD BE CHECKED REGULARLY TO INSURE THAT THEY ARE NOT LEAKING AND REPAIRED AND/OR REPLACED WHENEVER LEAKS ARE NOTICED.

PREVENTATIVE MAINTENANCE (CON'T)

ALL PIPE CONNECTIONS SHOULD BE CHECKED REGULARLY TO INSURE THAT THEY ARE NOT LEAKING PRODUCT OR PERMITTING THE INCORPORATION OF AIR INTO THE PRODUCT WHICH WOULD CAUSE FOAM.

ALL CASES, CONVEYORS, AND STACKERS SHOULD BE MAINTAINED IN PROPER OPERATING CONDITION TO AVOID JAMMING AND SUBSEQUENT LOSS OF PRODUCT FROM SPILLAGE OR BROKEN PACKAGES.

FILLER VALVES SHOULD BE CHECKED TO SEE THAT THEY ARE NOT LEAKING PRODUCT AND ARE FILLING PRODUCT TO THE CORRECT CAPACITY. IN GLASS OR PLASTIC BOTTLES, FILLING TO THE CAP SEAT MAY CREATE SPILLAGE WHEN THE MILK WARMS UP.

PLASTIC AND GLASS BOTTLE FILLERS AND CAPPERS SHOULD BE MAINTAINED IN EXCELLENT CONDITION TO AVOID BREAKAGE AND PRODUCT LOSSES. A REGULAR MAINTENANCE PROGRAM SHOULD BE ADOPTED TO MAINTAIN THESE MACHINES IN TOP OPERATING CONDITION TO AVOID JAM AND PRODUCT SPILLAGE.

CENTRIFUGAL MACHINES SHOULD BE CHECKED TO INSURE THAT SEALS ARE MAINTAINED IN GOOD CONDITION TO PREVENT LEAKAGE OF PRODUCT.

PREVENTATIVE MAINTENANCE (CON'T)

HIGH LEVEL CONTROLS SHOULD BE CHECKED TO MAKE SURE THAT THEY ARE IN CONTINUOUS OPERATING CONDITION.

INSPECTION OF LINES TO MAKE SURE THAT THEY ARE PROPERLY PITCHED TO DRAIN AND AS FREE AS POSSIBLE FROM VIBRATION. LINE VIBRATION CAN CREATE LEAKING JOINTS AND GASKETS.

REGULARLY REPAIR AND/OR REPLACE ALL WORN AND OBSOLETE EQUIPMENT.

DAILY INSPECTIONS BY THE PERSONNEL RESPONSIBLE FOR MAINTENANCE TO IDENTIFY IMPROPERLY OPERATING EQUIPMENT. FAULTY EQUIPMENT SHOULD BE REPAIRED AS RAPIDLY AS POSSIBLE.

DAILY WASTE MANAGEMENT PRACTICES

RECEIVING OPERATIONS

-- MAKE SURE THAT EACH TANK IS PROPERLY CONNECTED TO THE TRANSFER PUMP ON INITIAL UNLOADING OF THE FIRST TANK DAY; CHECK SHOULD BE MADE TO INSURE THAT ALL COUPLINGS AND PUMP SEALS ARE NOT LEAKING. IMMEDIATE ATTENTION SHOULD BE GIVEN TO ATTEMPTING TO CORRECT ANY LEAKS THAT ARE OBSERVED. IF LEAKS CANNOT BE CORRECTED, THEN A REQUEST SHOULD BE MADE TO MAINTENANCE TO MAKE REPAIRS.

-- TANK TRUCKS SHOULD NOT BE PERMITTED TO STAND MORE THAN ONE HOUR PRIOR TO UNLOADING. LONG STANDING OF TANK TRUCKS IN THE QUIESCENT STATE PERMITS CREAMING AND ONCE CREAMING OCCURS, EVEN EXTENSIVE AGITATION WILL NOT PREVENT ADHERENCE OF THE CREAM MATERIAL TO THE SIDES OF THE TANK.

-- ALLOW ADEQUATE TIME FOR THE TANK TRUCK TO DRAIN PRIOR TO DISCONNECTING THE TRANSFER HOSE. CARE SHOULD BE TAKEN TO SHOW THAT ALL PRODUCT IN THE TRANSFER HOSE HAS BEEN PROPERLY EMPTIED PRIOR TO DISCONNECTING THE TANK.

PROCESSING

-- ALL SANITARY FITTINGS, VALVES, ROTARY SEALS, PUMP PARTS, AND FILLER PARTS MUST BE HANDLED WITH EXTREME CARE DURING EVERY PHASE OF OPERATION TO PREVENT DAMAGE TO THE SURFACE WHICH MAY CAUSE LEAKS. SMALL PARTS SHOULD BE PROPERLY WASHED IN SMALL PARTS WASHERS AND PLACED ON RUBBER MATS FOR DRAINING TO MINIMIZE ANY DAMAGE.

-- DO NOT USE A CONSTANT RUNNING WATER HOSE IN ANY AREA.

-- EMPLOYEES SHOULD EITHER ELIMINATE THE CAUSE OF SPILLAGE OR REPORT IT TO THE WASTE CONTROL SUPERVISOR RATHER THAN WASHING AWAY SPILLED PRODUCT. VALVES, PIPELINES, PUMPS SHOULD BE PROPERLY INSTALLED, AND GASKETS INSTALLED AND CAREFULLY SEATED TO PREVENT LEAKAGE.

-- THOROUGHLY DRAIN ALL LINES, TANKS, AND PROCESSING VATS BEFORE RINSING. THE PROCESS EQUIPMENT SURFACES SHOULD BE RINSED AS SOON AS POSSIBLE AFTER USE SO THAT THE PRODUCT DOES NOT DRY ON AND INCREASE CLEANING REQUIREMENTS.

-- MAKE SURE THAT ALL LINES ON THE SUCTION SIDE OF PUMPS ARE PROPERLY SEALED TO AVOID AIR LEAKS AND RESULTANT FOAMING WHICH CAN CAUSE EXCESSIVE WASTE.

PROCESSING (CON'T)

-- MAKE SURE THAT CORRECT CONNECTIONS ARE MADE ON PLATE TYPE HEAT EXCHANGERS SO THAT THERE IS NO POSSIBILITY OF MILK BEING PUMPED TO THE WATER SIDE OF THE EXCHANGER OR WATER BEING PUMPED TO THE MILK SIDE.

-- MAKE SURE THAT ALL WORN AND OBSOLETE EQUIPMENT IS OBSERVED DURING PLANT OPERATIONS AND REPORTED TO MAINTENANCE FOR REPAIR.

-- DRIPS AND LEAKS OCCURRING DURING PROCESSING RUNS SHOULD BE CORRECTED IF POSSIBLE, AND IF IT IS NOT POSSIBLE THEN THE DRIPS SHOULD BE COLLECTED IN CONTAINERS AND NOT ALLOWED TO GO DOWN THE DRAINS.

-- WHERE DRIP SHIELDS ARE SUPPLIED, THEY SHOULD BE IN PLACE AND PROVIDED WITH ADEQUATE CONTAINERS FOR EACH DAY'S OPERATION.

-- FOR PROCESSING VATS THAT ARE NOT SUPPLIED WITH HIGH LEVEL SHUT-OFF CONTROLS, THE EMPLOYEE RESPONSIBLE FOR FILLING THE PROCESSING VAT SHOULD PAY CAREFUL ATTENTION TO THE FILLING OPERATIONS SO THAT OVERFLOWS DO NOT OCCUR.

PACKAGING AND HANDLING OF PRODUCTS

-- ALL BOTTLES SHOULD BE INSPECTED CAREFULLY AT THE BEGINNING OF THE BOTTLE WASHING OPERATIONS SO THAT DEFECTIVE BOTTLES DO NOT GET TO THE FILLER AND THUS AVOID PRODUCT LOSSES.

-- FOR PLASTIC AND GLASS BOTTLE FILLERS, CAPPERS SHOULD BE MAINTAINED IN FIRST CLASS CONDITION TO AVOID BREAKAGE AND/OR PRODUCT LOSS.

-- PAPER FILLING MACHINES MUST BE MAINTAINED IN PROPER OPERATING CONDITION DURING OPERATION. SETTINGS ON PAPER FORMING EQUIPMENT SHOULD BE CHECKED FREQUENTLY TO INSURE PROPER PACKAGE FORMATION AND SEALING TO MINIMIZE LEAKING.

-- FILLER VALVES SHOULD BE CHECKED TO SEE THAT ALL CONTAINERS ARE FILLED TO CORRECT CAPACITY. IN GLASS BOTTLES, FILLING TO THE CAP SEAT MAY CREATE SPILLAGE WHEN MILK IS FORCED UP BY THE CAP BEING FORCED PAST THE CAP SEAT WITH TEMPERATURE CHANGES.

-- OPERATORS SHOULD CHECK THE FILLER SUPPLY BOWL FOR FOAM AND ELIMINATE ANY FOAM TO MINIMIZE SPILLAGE AND PROPER OPERATION OF PACKAGING MACHINE.

PACKAGING AND HANDLING OF PRODUCTS (CON'T)

-- BOTTLES, PLASTIC AND PAPER CONTAINERS SHOULD BE HANDLED CAREFULLY DURING CASING, STACKING, LOADING, AND DELIVERING TO AVOID PRODUCT LOSSES.

-- SPILLED DRY INGREDIENTS SHOULD NOT BE WASHED DOWN THE DRAIN BUT HANDLED AS A SOLID WASTE.

CLEANING AND SANITIZING WASTE WATER HANDLING

-- CARE SHOULD BE TAKEN TO AVOID INCORPORATION OF CLEANING COMPOUNDS AND/OR SANITIZING SOLUTIONS INTO MILK PRODUCTS, THUS ELIMINATING THE NEED FOR DISPOSAL OF LARGE QUANTITIES OF MILK SOLIDS.

-- CONCENTRATION OF CLEANING AND SANITIZING COMPOUNDS NEEDS TO BE CAREFULLY CONTROLLED. WHERE CLEANING COMPOUNDS ARE ADDED BY HAND, ONLY SUFFICIENT CLEANING COMPOUNDS NECESSARY TO INSURE ADEQUATE CLEANING AND SANITIZING SHOULD BE USED TO MINIMIZE DISCHARGE OF POTENTIALLY TOXIC MATERIALS OR WASTED AT EXCESSIVELY HIGH OR LOW pH LEVELS.

COTTAGE CHEESE OPERATIONS

-- EMPLOYEES SHOULD BE PAYING PARTICULAR ATTENTION TO CHEESE VATS DURING FILLING SO THAT THEY WILL NOT BE OVERFLOWED WITH SUBSEQUENT LOSS OF PRODUCT TO THE DRAIN. LIQUID LEVEL IN THE CHEESE VATS SHOULD BE AT LEAST THREE INCHES BELOW THE TOP EDGE OF THE VAT TO PREVENT SPILLAGE DURING AGITATION. ALL VALVES, PUMPS AND LINE FITTINGS SHOULD BE CHECKED ON A DAILY BASIS TO MAKE SURE THAT THEY ARE LEAK FREE.

-- ALL SPILLS OF CURD PARTICLES FROM CHEESE OPERATIONS SHOULD BE SWEPT UP AND HANDLED AS SOLID WASTE AND NOT WASHED DOWN THE SEWER DRAINS.

-- USE PROPER MANUFACTURING PRACTICES TO MINIMIZE FINES IN WHEY.

ICE CREAM OPERATIONS

-- AVOID OVERFILLING ICE CREAM MIX VATS TO ELIMINATE THE SPILLAGE OF HIGH BOD-CONTAINING MATERIALS DURING AGITATION. DURING FILLING, ATTENTION SHOULD BE MAINTAINED ON THE FILLING OPERATION TO AVOID OVERFLOW.

-- FOOD STUFFS AND OTHER DRY INGREDIENTS FROM ICE CREAM OPERATIONS SHOULD BE SWEPT UP AND TREATED AS SOLID WASTE.

-- ICE CREAM MIX HAS A VERY HIGH BOD LEVEL AND FROZEN PRODUCTS THAT ARE DUMPED ON THE FLOOR DURING FILLER BREAKDOWNS SHOULD NOT BE WASHED DOWN THE DRAIN BUT PLACED IN A CONTAINER FOR HANDLING EITHER AS A HIGH SOLIDS WASTE OR FOR ANIMAL FEED.

APPENDIX 5. ANALYSES

Not all of the following analyses will be required on a routine, daily basis to characterize the wastewaters from individual dairy plants. (See 43 for more details.) However, a complete list is included here.

A. Biochemical Oxygen Demand (BOD)

This is a measure of the amount of oxygen required by microorganisms to assimilate any available nutrients in a liquid system into microbial cells, in five days at 20 C.

This test is of an empirical nature and determines the reduction of dissolved oxygen in a closed system, containing a sample of the wastewater diluted with oxygen-saturated water and a small quantity of seed material containing acclimated microorganisms. The oxygen content of the system is measured before and after incubation at 20 C for 5 days.

Commercially available equipment has significantly increased the ease of determination of BOD without affecting the accuracy of the test.

B. Chemical Oxygen Demand (COD)

This is a measure of the amount of oxygen in a sample which may be oxidized by a strong chemical oxidant.

With certain wastes containing substances toxic to microorganisms this test, or a total organic carbon determination (see below), may be the only method for determining the organic load. Where wastes contain only readily available organic bacterial food and no toxic matter, however, the results can be used to approximate the ultimate carbonaceous BOD values. A full analysis takes about 3 hours, as against 5 days for a BOD.

The test utilizes a reflux boiling for 2 hours of the sample with a known amount of potassium dichromate and sulphuric acid and the excess dichromate is titrated with ferrous ammonium sulphate. The amount of oxidizable organic matter, measured at oxygen-equivalent, is proportional to the potassium dichromate consumed.

C. Total Organic Carbon (TOC)

This is a measure of the total amount of organic carbon present in a sample. It is a more direct expression of the organic chemical content of water than either of the other 2 analyses and can be used to monitor processes for the treatment or removal of organic contaminants without undue **dependence on the oxidation step. This can be done at low concentrations and a sample can be analyzed using instrumental** techniques in only a few minutes.

D. Settleable Solids

These, as the name implies, are those solids which will settle in a graduated Imhoff cone within one hour. The cone, a cylindrical tapered vessel, retains the volume of solids which have settled. These are measured and recorded as ml/l. The gravimetric version of this test may also be used.

E. Suspended Solids (SS)

This is a measure of the total nonfilterable residue which is the material retained on a standard glass fiber filter dish after filtration. The residue is dried at 104 C for 1 hour. It is the material generally removed as a sludge during primary treatment.

F. Total Solids (TS)

This is the same standard test as used for milk and dairy products and requires the measurement of the total amount of material, dissolved and suspended, which remains in the pre-weighed nickle basin after evaporation and heating to 104 C for 4-1/2 hours.

G. Milk Fat

The fat concentrations are measured by the Werner-Schmidt fat test. This involves acid digestion of a known sample volume and extraction of the fat with a series of solvents. The separated solvents are evaporated off, leaving behind the fatty material, which is then weighed. The Werner-Schmidt test is preferred to the Babcock or Gerber tests because of its increased sensitivity, particularly for low fat concentrations.

H. Total Nitrogen

The measurement of total nitrogen is made by the widely used Kjeldahl method.

I. Lactose

The method for determining lactose in dairy effluents is using a 5% phenol solution and concentrated sulphuric acid as colorimetric reagents, and it is a modification of a method for estimating sugar and related substances suggested by DeBois, et al., 1956. The result is reported as lactose monohydrate (35).

APPENDIX 6. PUBLIC LAW 92-500

Sec. 201(g)(1)

The Administrator is authorized to make grants to any state, municipality, or intermunicipal or interstate agency for the **construction of publicly owned treatment works.**

Sec. 201(g)(3)

The Administrator shall not approve any grant . . . unless . . . such treatment works are not subject to excessive infiltration.

Sec. 204(b)(1)(A)

Sec. 204(b)(1)(B)

Sec. 204(b)(2)

Sec. 204(b)(2)

The Administrator shall . . . issue guidelines . . . which shall establish (a) classes of users . . . including . . . industrial users, (b) criteria . . . to determine the adequacy of charges . . . (c) model systems and rates of user charges typical of . . . municipal industrial communities.

However, experiences dictated that there are a number of differences between the law and local sewer use ordinance requirements. One must know what specifically does EPA require in a sewer use ordinance and under what authorities EPA requires more strict limitations. Industry does need to work with local governments to help standardize requirements and prevent unnecessary restrictions. Specific requirements for sewer use ordinances that are required by Federal law if Federal monies are received include the following:

1) New connections from flow sources into the sanitary sewers are prohibited.

2) New sewers and connections must be properly designed and constructed.

3) A user charge system must be incorporated in the bill. An equitable system of cost recovery must be instituted and all users must pay the user charge, not just the industrial users.

4) Users shall be required to immediately notify the waste treatment plant of any unusual discharge, either flow or waste.

5) Pretreatment should be required of waste that would otherwise be detrimental.

6) Users' charges should be reviewed annually.

7) Industrial users must remit their portion of the grant amount allocable to the treatment of their wastes.

Sewer Ordinances - Surcharges, Restrictions and Pretreatment

Sewer use ordinances are commonly drafted by city engineers and city legal people. They frequently use model ordinances. Model ordinances include the following:

1) WPCF MOP No. 3 - Regulation of Sewer Use - 1975.

2) APWA - Special Report No. 23 - Guidelines for Drafting a Municipal Ordinance on Industrial Wastes Regulations and Surcharges - 1971.

3) WRRI - UNC - Surcharges for Industrial Waste; Suggestions and Guidelines - 1972.

4) League of municipalities has model ordinances that are often used

5) The Uniform Ordinance Subcommittee of the Industrial Waste Committee of the California Water Pollution Control Association compiled a model wastewater discharge ordinance in April of 1974.

A sewer use ordinance contains a number of standard items. The sections that are commonly found are as follows:

(1) Preamble - this is the whereas that establishes the reason for the ordinance; (2) Definitions - definitions that relate to this specific ordinance. Use of public sewers is required; (3) Use of sewers is noted with any further additions and/or regulations; (4) The power and authority of the inspectors is granted; (5) Surcharge or user charge is established with sampling, analysis, and formula provided; (6) Enforcement in penalties are noted; (7) Conflict clause; (8) A review process clause; and (9) An effective date.

Plant management should be especially wary of a number of key factors in ordinances that may affect their control program. Some questions to be asked are as follows:

1) What is the ordinance going to cost the plant as it is proposed after enactment?

2) Are there defacto or real limitations prohibiting the discharge from your plant?

3) How much control is given to the engineering manager of the utilities department, or is the control left with the town council?

4) Who is the individual who handles complaints and reviews decisions?

5) Will samples taken of your wastewater be representative and who pays for the cost of the samples?

6) Are there unrealistic limitations on parameters such as pH, FOG, BOD5?

7) Did you review the ordinance before its enactment?

8) Can you obtain split samples? In other words, will the city take samples and give you one-half and let them take one-half so that you can send the samples out to an independent laboratory to confirm their results?

9) Can you object to unreasonable results, and what actions are possible by you and the city?

Past experience indicates that changes can be made if management is persistent and knowledgeable.

Problem areas presented in local sewer use ordinances include the following:

1) No public notice was given that the sewer use ordinance or amendments were being made.

2) The town council declared an emergency, which allowed them to have no public notice to consider the sewer use ordinances or amendments.

A common problem area is misunderstanding of what is really required for the city to have in a sewer use ordinance. There are only four or five requirements that must be included in sewer use ordinances.

A real problem is that consulting engineers use model ordinances. It is much easier for them to adapt a model ordinance than it is for them to take the time to specifically develop an ordinance to your local conditions.

Another real problem is that governing bodies such as the town coucil which usually passes sewer use ordinances, have not knowledge about BOD or your particular wastewater situation. It is your responsibility to see that they gain this knowledge.

Specific problems have been noted in local sewer use ordinances for food plants. Specifically, for dairy plants, the following problems have been noted:

1) Holding tanks being required for flow equalization.

2) The requirements for the construction of a controlled manhole or sampling facility might cost the plant as much as $25,000 or more.

3) Limitations or prohibitions on wastewater discharge that would prohibit the plant from operating.

4) The requirement that production records be released on all products, which becomes a matter of public record.

5) Wording in the sewer use ordinances for samples so that non-representative samples are obtained of your wastewater, which can be very costly.

6) The requirement that surcharges be based on water metered into the plant. Dairy plants discharge as little as 45% of the metered water-in as wastewater. These plants, if paying on the basis of metered water, then pay twice the surcharge they should be paying.

7) Complete authority given to the engineering manager. This may be included without any review or procedure to file exceptions.

8) Surcharge charged for industrial users only. EPA requires that user charges be charged for all users. Municipalities commonly eliminate a number of large contributors of waste load such as laundry mats, motels, restaurants, private facilities, who should be paying user charges or surcharges. Then the total bill for industrial users is divided among only the larger users and contributors of wastewater. Therefore, the surcharge bill is more than it should be.

A real problem presented in many sewer use ordinances is that monitoring and analysis of costs are prohibited. These costs are usually passed on in the surcharges and user charges. Experience indicates that monitoring and analysis cost may be more than 20-25% of your surcharge bill. Analysis and monitoring needs to be on a realistic basis.

Specific steps can be taken in correcting either an unreasonable new sewer use ordinance or amendments to a current sewer use ordinance. The specific steps that can be taken are as follows:

1) Use a local lawyer to represent yourself.

2) Make sure that the local lawyer obtains outside legal and technical advice from a source familiar with food plant wastes.

3) Find individuals on your local authority that will be willing to listen to your position with an open mind.

4) Establish your position in regards to the proposed ordinance.

5) Be friendly but firm in requesting changes, and minimize the number of changes you wish to make.

6) Do not say that you do not like Part 5, Section 2, Item A; put a proposed change in ordinance language to them for consideration.

7) Get help from other industries and business groups who will be confronted with similar problems from the ordinance.

8) Plan a united effort and get the other groups to work with you.

9) Use public and private meetings to your best interest.

10) Present a valid attack on specifics in the ordinance.

11) Make sure that your lawyer and technical and legal advisers know what the city is required to do.

APPENDIX 7. REPRESENTATIVE PREVENTIVE MAINTENANCE SCHEDULE FOR A MILK, ICE CREAM, AND COTTAGE CHEESE PLANT

I. Milk and Cheese Area

A. Monthly Schedule

1. St. Regis Homogenizer
2. Gallan Homogenizer (monthly and 6 month)
3. Pure-Pak Model TP
4. Pure-Pak Model LL
5. Pure-Pak Model WP
6. Ramey Gallon Filler
7. Pure-Pak Model WP (weekly evaluation)
8. Pump seals
9. CIP air activated valve O rings and valve seat
10. CIP filters
11. High level, low level controls
12. Agitator connections on storage tanks

Homogenizer Maintenance Check Includes:

1. Check and tighten all bolts, nuts and fittings.
2. Check condition and tension of drive belts.
3. Check main drive shaft seal.
4. Check sub-shaft seal for leaks.
5. Check suction discharge valve, grind valve as required.

Milk Filler Monthly Check Includes:

1. Check index rollers and studs for freedom of rolling and freedom from flat spots.
2. Check Mandrel plate and Convayer index plate.
3. Check all air and water lines for leaks.
4. Check all air cylinders for proper operation.
5. Check carbon brushes on variable transformer.
6. Check rotary water joint.
7. Check contacts per motor starter.
8. Check vacuum pump for coupling condition, check vacuum level with solenoid closed, oil and vacuum lines for leaks, check pump bearings, check for oil leaks seals.

The Weekly Filler Check on the Pure-Pak Model WP Includes the Following:

1. Feeder unit

    a. Check cam rollers and studs

   - b. Check timing loading on feeder
   - c. Check bumper for nozzle carriage
   - d. Check vacuum valve for freedom of leaks
   - e. Check tension and loading panel chain

2. Bottom sealing unit

   - a. Check ignition rod and wire
   - b. Check cams, key set, set screws
   - c. Check loose spindle locks on cam
   - d. Check rotory joint
   - e. Clean super heat nozzle holes
   - f. Check catalytic screen
   - g. Check condition of index plate roller

3. Breaker unit

   - a. Breaker wing adjustments
   - b. Bumper shims

4. Filler unit

   - a. Check filler pads

5. Top heating the ceiling unit

   - a. Check complete dating assembly

6. Electrical system

   - a. Check for loose terminals
   - b. Check that microswitches are operative
   - c. Check main drive belt for wear

B. 3 Month Check

1. Remy milk packaging machine
2. Federal vacumatic milk filler
3. Pure-pak model TP
4. Pure-pak model LL
5. Blow molding equipement
6. Caser-destacker, washer, rinser and conveyors
7. Cottage cheese filler
8. Federal twin caser
9. Conveyor specialties milk case stacker
10. Conveyor specialties cheese case stacker
11. Conveyor specialties milk carton caser
12. LP stacker
13. WP Pure-pak
14. Remey gallon filler
15. Air eliminator
16. Air blow system

17. Air compressor filters

II. Ice Cream and Novelty Area

A. Weekly Schedules

1. Automatic stick insertor for novelty machines

B. Monthly Schedules

1. Model 12 Vita-Line
2. Diamond automatic stick insertor
3. Henderson wrapper
4. Anderson bar stacker
5. Anderson carton former and sealer
6. Sleever
7. Anderson plastic wrap
8. Anderson shrink towel
9. Anderson half-gallon filler
10. Gallon filler

C. Ice Cream Maintenance Every Two Months Schedule:

1. CREPACO ice crean freezer
2. St. Regis continuous ice cream machine

D. Ice Cream Maintenance Every 3 Months Schedule

1. Morpak carton master
2. Lynch sandwich machine

E. Ice Cream Maintenance Yearly Schedule

1. St. Regis continuous ice cream freezer
2. Instant freezer

APPENDIX 8. REFERENCES

1. American Public Health Association. 1975. "Standard Methods for Examination of Water and Industrial Wastes." 14th Ed. APHA, Washington, D.C.

2. Analytical Quality Control Laboratory. 1972. Handbook for Analytical Quality Control in Water and Wastewater laboratories. U. S. EPA Technology Transfer.

3. Anonymous. 1970. Sewer Services and Charges. Urban Data Service, Vol 2(2). International City Management Assoc. pps. 6-32.

4. Anonymous. 1973a. Federal Register, Vol. 38(215). Pretreatment Standards. Thursday, Nov. 8, 1973. pps. 30982-30984.

5. Anonymous. 1973b. Federal Register, Vol. 38(161). Grants for Construction of Treatment Works - User Charges and Industrial Cost Recovery. Tuesday, August 21, 1973. pps. 22524-22527.

6. Anonymous. 1974a. Code of Federal Regulations Part 40, Subpart E. February 11, 1974. p. 241.

7. Anonymous. 1974b. Code of Federal Regulations Part 40, SubpartE. February 11, 1974. p 247.

8. Anonymous. 1974c. Federal Register, Vol. 39(29). Final Construction Grant Regulations. Monday, Feburary 11, 1974. pps. 5552-5270.

9. Anonymous. 1974d. Model Wastewater Discharge Ordinance. California Water Pollution Control Assoc., Berkeley, California.

10. British Standards Institution. 1963. B. S. 1741; Methods for the Chemical Analysis of Liquid Milk and Cream.

11. Carawan, R. E., 1973., V. A. Jones and A. P. Hansen. 1972. Water and Wastewater Management in Dairy Processing. p. 132. WWRI No. 79., University of North Carolina, Raleigh.

12. Carawan, R. E. 1973. Relating Sewer Use Ordinances and Surcharges to the Food Industry. Unpublished Manuscript. N. C. State University, Raleigh.

13. Carawan, R. E., 1975. Municipal Water and Wastewater Charges for Dairy Processing Plants. Unpublished Manuscript. N. C. State University, Raleigh.

14. Carawan, R. E. 1977. PhD. Dissertation. The Ohio State University, Columbus; W. J. Harper, Adviser.

15. Carawan, R. E. and V. A. Jones. 1977. Water and Waste Management Educational Program for Dairy Processing. J. Dairy Sci., 60:1192.

16, Carawan, R. E., V. A. Jones and A. P. Hansen. 1977. **Wastewater Characteristics in a Multiproduct Dairy.** In Press.

17. Carawan, R. E., V. A. Jones and A. P. Hansen, 1977. Water Use in a Multiproduct Dairy. In Press.

18. Cleary, E. J. 1971. Guidelines for Drafting a Municipal Ordinance on Industrial Waste Regulations and Surcharges. Special Report No. 23. American Public Works Assoc., Chicago.

19. Clements, E. V. 1975. Sewer Surcharges. How to Ease the Spiraling Cost of Wasterwater Discharge. Canner/ Packer 144(7):71-73.

20. Elliott, R. A. 1973. New Wastewater Practices in Dairy Plants. J. Milk Food Technol. 36(9):453-455.

21. Elliott, R. A. 1977. Safeway Plans New San Leandro Plant as "Energy Saver". Am. Dairy Rev. 39 (7):24, 26, 28, 30, 32, 34.

22. Harper, W. J., J. L. Blaisdell and J. Grosskopf. 1971. Dairy Food Plant Wastes and Waste Treatment Practices. U. S. Environmental Protection Agency, 12060 EGU 03/71. **Washington, D.C.**

23. Harper, W. J. 1972. Control of Fluid Wastes in the Dairy Industry. Dairy and Ice Cream Field 155:46.

24. **Jelen, Pavel and W. Buchheim. 1976. Norwegian "Whey** Cheese". Food Technol. 30(11);62-74

25. Jonas, J. J., T. W. Craig, R. L. Huston, E. H. Marth, E. W. Speckman, T. F. Steiner, and S. M. Weisberg. 1976. Dairy Products as Food Protein Resources. J. Milk Food Technol. 39(11)778-795.

26. Jones, H. R. 1974. "Pollution Control in the Dairy Industry." Noyes Data Corporation, Park Ridge, New Jersey.

27. Jones. V. A. 1959. "Is Water 'Drowning' Profits in Your Plants?". Milk Product J. 50(7);10.

28. Lanvin, A. A. 1968. Industrial Waste Ordinance Enforcement Helps Abate Pollution at Chicago. Water and Waste Eng. 5(9):27,29.

29. Loewenstein, M., M. B. Reddy , C.H. White, S. J. Speck and T. A. Lunsford. 1975. Using Whey in Ice Cream. Dairy and Ice Cream Field __(Nov.):22-50.

30. Lough, R. C. 1958. "Planning and Making Trade Waste Surveys." Pollution Advisory Council Publication No. 3. Government Printer, Wellington, N. Z.

31. McPhee, W.T. and I. Rosenstein. 1974. How to Get the Most from Industry-Municipality Pacts. Water and Wastes Eng., January. pps. A-11 to A-24.

32. Massey, D. T. and L. H. Dunlap. 1975. Federal Water Pollution Control Act Amendments of 1972+ Construction Grants for Sewage Treatment Works and Effects on Industries. Law School, University of Wisconsin, Madison.

33. Meat Research Institute of New Zealand. 1966. Standard Methods for the Examination of Meat Wastes and Receiving Waters.

34. Milk Industry Foundation (MIF). 1967. "Manual for Milk Plant Operators". 3rd Edition. Milk Industry Foundation, Washington, D. C.

35. Ministry of Agriculture, Fisheries and Food. 1969. "Dairy Effluents". HMSO, London.

36. New Zealand Dairy Research Institute. 1977. Proceedings of the 50th Jubilee Conference, March. New Zealand Society of Dairy Science and Technology.

37. Nickerson, T. A. 1976. Use of Milk Derivatives, Lactose in Other Foods. J. Dairy Sci. 59(3) 581-587.

38. Pai, J. T. 1976. Personal Communication.

39. Schingoethe, D.J. 1976. Whey Utilization in Animal Feeding. J. Dairy Sci. 59(3) 556.

40. U. S. Department of Interior. 1974." Water Measurement Manual." 2nd Edition. U. S. Department of Interior, Denver, Colorado.

41. U. S. Environmental Protection Agency. 1971. Federal Guidelines for Equitable Recovery of Industrial Waste Treatment Costs in Municipal Systems. U. S. Environmental Protection Agency, Washington, D.C.

42. U. S. Environmental Protection Agency. 1973. Federal Guidelines for Pretreatment of Pollutants Introduced into Publicly Owned Treatment Works. U. S. Environmental Protection Agency, Washington, D. C.

43. U. S. Environmental Protection Agency. 1973. "Handbook for Analysis of Wastewaters". U. S. Environmental Protection Agency, Technology Transfer, Cincinnati, Ohio.

44. U. S. Environmental Protection Agency. 1973. "Handbook for Monitoring Industrial Wastewater." U. S. Environmental Protection Agency, Technology Transfer, Cincinnati, Ohio.

45. U. S. Environmental Protection Agency. 1974. Federal Guidelines-User Charges for Operating and Maintenance of Publicly Owned Treatment Works. 39 Federal Register 5270. U. S. Environmental Protection Agency, Washington, D. C.

46. U. S. Environmental Protection Agency. 1976. Municipal Wastewater Treatment Works Construction Grants Program. U. S. Environmental Protection Agency. Washington, D. C.

47. Walstra, P. and H. Mulder. 1963. Neth. Milk Dairy J. 17:334.

48. Washburn, J.E. 1975. Critique on User Charges Under the Federal Water Pollution Control Act. N. C. Conference on Water Conservation. Water Resources Institute of the University of N.C., Raleigh.

49. Watson, C. W. 1961. "Your Dairy Waste Line is Showing". Milk Industry Foundation Convention Proceedings, pp. 12-24.

50. Watson, C. W. 1965. "Dairy Products" Chapter 5 in "Industrial Waste Control" C. F. Gurnham, Ed. Academic Press, New York, N. Y.

51. Watson, K. S. and A. E. Peterson. 1977. Benefits of Spreading Whey on Agricultural Land. Journal WPCF 49(1):24-34.

52. Water Pollution Control Federation. 1975. Regulation of Sewer Use. WPCF Manual Practice No 3. Water Pollution Control Federation, Washington, D. C.

53. Water Resources Research Institute. Surcharges for Industrial Wastes: Suggestions and Guidelines. Water Resources Research Institute of the University of North Carolina, Raleigh, N. C.

54. Williams, R. T. 1974. Use of a Municipal Permit Program for Establishing Fair Wastewater Service Charges. **Proceedings Fifth National Symposium on Food Processing** Wastes. U. S. Environmental Protection Agency. (EPA - 660/2-74-058), Corvallis, Oregon. pps 31-52.

55. Wooding, N. Jr., 1968. Waste Management, Treatment and Disposal for the Food Processing Industry. Special Circular 113. Penn. State University, University Park, Pa.

56. Zall, R. R., and W. K. Jordan. 1969 Monitoring Milk Plant Waste Effluent - A New Tool for Plant Management. J. Milk Food Technol. 32:197.

57. Zall, R. R., and W. K. Jordan. 1973. Upgrading Production Facilities to Control Pollution In-Plant Control of Waste. Technology Transfer Design Seminar, Madison, Wisconsin. March 20-21.